Technical Report 1096

Digital Procedural Skill Retention for Selected M1A2 Tank Inter-Vehicular Information System (IVIS) Tasks

William R. Sanders
U.S. Army Research Institute

August 1999

19990922 027

United States Army Research Institute for the Behavioral and Social Sciences

Approved for public release; distribution is unlimited.

DTIC QUALITY INSPECTED 4

U.S. Army Research Institute
for the Behavioral and Social Sciences

A Directorate of the U.S. Total Army Personnel Command

EDGAR M. JOHNSON
Director

Technical Review by

Douglas H. Macpherson
Jean L. Dyer
David W. Bessemer

NOTICES

DISTRIBUTION: Primary distribution of this Technical Report has been made by ARI. Please address correspondence concerning distribution of reports to: U.S. Army Research Institute for the Behavioral and Social Sciences, Attn: TAPC-ARI-PO, 5001 Eisenhower Ave., Alexandria, VA 22333-5600.

FINAL DISPOSITION: This Technical Report may be destroyed when it is no longer needed. Please do not return it to the U.S. Army Research for the Behavioral and Social Sciences.

NOTE: The findings in this Technical Report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.

REPORT DOCUMENTATION PAGE

1. REPORT DATE (dd-mm-yy)	2. REPORT TYPE	3. DATES COVERED (from. . . to)
August 1999	Final	September 1996 – September 1998

4. TITLE AND SUBTITLE	5a. CONTRACT OR GRANT NUMBER
Digital Procedural Skill Retention for Selected M1A2 Tank Inter-Vehicular Information System (IVIS) Tasks	5b. PROGRAM ELEMENT NUMBER 0602785A
6. AUTHOR(S) William R. Sanders	5c. PROJECT NUMBER A790
	5d. TASK NUMBER 2228
	5e. WORK UNIT NUMBER H01

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)	8. PERFORMING ORGANIZATION REPORT NUMBER
U.S. Army Research Institute for the Behavioral and Social Sciences ATTN: TAPC-ARI-IK 2423 Morande St. Fort Knox, KY 40121	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. MONITOR ACRONYM
U.S. Army Research Institute for the Behavioral and Social Sciences 5001 Eisenhower Avenue Alexandria, VA 22333-5600	ARI
	11. MONITOR REPORT NUMBER Technical Report 1096

12. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT (Maximum 200 words):

The U.S. Army Force XXI program makes extensive use of digital communications technologies to speed the exchange of information among all operational levels. While digital communications offers great potential, anecdotal reports from field trials and testing repeatedly state that the basic procedural skills needed to operate these systems are highly perishable. The present research developed estimates of digital procedural skill retention for the tasks of creating and sending digital map overlays and reports, using the M1A2 Abrams tank Inter-Vehicular Information System. Twenty-eight soldiers received instruction based on the M1A2 New Equipment Training Team lesson plan, followed by an immediate evaluation of task performance, and a follow-on evaluation 30 days later. Results showed a 52 percent reduction in the number of soldiers able to create and send digital map overlays after the 30 day delay, and a 23 percent reduction in the number able to create and send digital reports. Methods for measuring skill decay are presented, and an approach to identify performance errors is provided.

15. SUBJECT TERMS

Inter-Vehicular Information System Skill Decay M1A2 Retention Digital Tasks

SECURITY CLASSIFICATION OF			19. LIMITATION OF ABSTRACT	20. NUMBER OF PAGES	21. RESPONSIBLE PERSON (Name and Telephone Number)
16. REPORT	17. ABSTRACT	18. THIS PAGE			
Unclassified	Unclassified	Unclassified	Unlimited	102	Mr. William Sanders, DSN 464-2613

Technical Report 1096

Digital Procedural Skill Retention for Selected M1A2 Tank Inter-Vehicular Information System (IVIS) Tasks

William R. Sanders
U.S. Army Research Institute

Armored Forces Research Unit
Barbara A. Black, Chief

U.S. Army Research Institute for the Behavioral and Social Sciences
5001 Eisenhower Avenue, Alexandria, Virginia 22333-5600

August 1999

Army Project Number
2O262785A790

Personnel Performance and Training Technology

Approved for public release; distribution is unlimited.

FOREWORD

As the Army prepares to fight on the digital battlefield, modern digital communications systems are being introduced that have the potential to greatly increase the capability to perform rapid and dispersed operations. Along with the increased capabilities, the new systems can also place great demands on the soldier's ability to accurately remember and perform long sequences of steps required to complete digital tasks. The goal of the present research was to develop estimates of digital procedural skill retention for a representative Army digital communications system, the M1A2 Abrams tank Inter-Vehicular Information System. Anecdotal accounts from field trials and testing repeatedly indicate that the basic procedural skills needed to operate digital systems are highly perishable, and that significant sustainment training is required to maintain these digital skills. The present research effort goes beyond anecdotal descriptions, measuring digital skill retention based on a controlled set of conditions. Performance measurement strategies and criteria for measuring skill retention are identified.

The research was performed by the Future Battlefield Conditions Team of the Fort Knox Armored Forces Research Unit (AFRU) of the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) under Work Package 2228, Force XXI Training Methods and Strategies (FASTTRAIN). ARI's research is supported by a Memorandum of Agreement between the U.S. Army Armor Center and Fort Knox and ARI entitled "Manpower, Personnel and Training Research, Development, Test, and Evaluation for the Mounted Forces," dated 16 October, 1995. This research was briefed to COL K. Gunzelman, Director, Mounted Maneuver Battlespace Lab.

ZITA M. SIMUTIS
Technical Director

ACKNOWLEDGEMENTS

The author wishes to acknowledge the essential contribution made by the soldiers of the U.S. Army Armor School's 16th Cavalry Regiment and First Armored Training Brigade who participated in the training and evaluation portions of the research. The present research was greatly shaped by the insights and recommendations of Army trainers. SFC Larry Adams of the Tank Commanders Certification Course provided early insights on digital task requirements and skill retention trends. The M1A2 New Equipment Training Team (NETT) led by Mr. Skip Ashton, and assisted by members of 2/16 F Troop, SFC Weisman, SSG Rethmeier, and SSG Vaghn provided great assistance detailing the NETT classroom training program. MAJ William Rademacher of ARI AFRU managed troop support, and assisted in the development of map overlay graphics for experimental tasks.

MAJ Joe Burns and Mr. Don Appler provided the use of the Fort Knox Mounted Warfare Test Bed facility for the project, while SGT Isarel Valera, and Mr. Dennis Goard, turned the requirements statement into a functioning research site. Data capture presented a significant technical challenge, which was met with the skilled support of the Fort Knox TV Division, headed by Mr. Bill Wallace. The timely support provided by Mr. Bob Demont, Mr. Dan Matola, and Mr. Ken Ott of General Dynamics Land System Division was essential for success.

While Drs. Jean Dyer and Doug MacPherson were reviewers for the present report, it must be acknowledged that their recommendations made a substantial contribution to both the form and content the final report. Dr. John Boldovici provided valuable guidance on statistical issues and the author is particularly indebted to Dr. David Bessemer for his patient support of this project, from the design stage through data analysis and results interpretation.

The present research effort owes its success in large part to the contributions of Mr. Mike Cobb of the Human Resources Research Organization. His mastery of digital systems training, and insights as an experienced leader won the respect of the soldiers and the research team. Additionally, the project leadership expertise of Dr. Kathy Quinkert, Future Battlefield Conditions Team Leader, was essential in overcoming the tremendous obstacles associated with acquiring the specialized equipment, contractor support, and organization cooperation necessary for this effort.

DIGITAL PROCEDURAL SKILL RETENTION FOR SELECTED M1A2 TANK INTER-VEHICULAR INFORMATION SYSTEM (IVIS) TASKS

EXECUTIVE SUMMARY

Requirement:

The U.S. Army's Force XXI program will field smaller yet more lethal divisions where soldiers will make extensive use of digital communications technologies to speed the exchange of information among all operational levels. While digital communications offer great potential, anecdotal reports from field trials and testing repeatedly indicate that the skills needed to operate these systems are highly perishable. The present research addressed three basic requirements. The first requirement was to develop empirically-based estimates of digital skill retention for selected M1A2 Abrams tank Inter-Vehicular Information System (IVIS) tasks which might be generalizable to other current and future systems. To meet this requirement it was necessary to develop estimates of skill acquisition, retention, and recovery. The second requirement involved investigating the contributions of key skill components to task success, to include procedural knowledge, declarative knowledge, and psychomotor skills. The third requirement was to develop a performance assessment methods that could be used by training developers to identify and address the source of recurring performance problems.

Procedure:

On Day 1, 28 soldiers received instruction based on the M1A2 New Equipment Training Team lesson plan, followed by an immediate evaluation consisting of four overlay and three report tasks. Soldiers successfully completing three or more overlays were identified as Overlay Skilled. Soldiers completing two or more report tasks were identified as Report Skilled. Psychomotor skill was assessed by presenting soldiers with a cursor positioning task. Declarative knowledge of task procedures was assessed with a multiple choice test. After a 30 day period without training (Day 30) the soldiers were again tested on four overlay, and three report tasks, as well as psychomotor skill and declarative knowledge of the tasks. Several strategies for estimating skill acquisition, retention, and recovery were applied to the data. A performance coding method was developed to identify the type and frequency of performance errors.

Findings:

The findings from the present research provide evidence that representative digital procedural skills will show significant skill decay after 30 days without sustainment training. Specifically, findings revealed a 52% reduction in the number of Overlay Skilled soldiers able to meet the three or more successful overlay trials criteria again after the 30 day retention interval. Results also showed a 23% reduction in the number of Report Skilled soldiers able to meet the two or more successful report trials criteria again after 30 days. Psychomotor skill associated with task performance did not show decay over 30 days. The data failed to show a significant relationship between psychomotor skill and Day 30 task success. Declarative knowledge of task procedures showed significant decay after 30 days, however this knowledge was recovered during the Day 30 trials. Study findings showed a significant relationship between declarative knowledge of task procedures and success on Day 30 tasks. The description of performance errors by task, subtask, and individual task step allowed for the identification of the potential source, and possible corrective actions for several performance problems.

Utilization of Findings:

The present research provides a "mark on the wall" skill retention estimate for representative M1A2 IVIS digital procedural tasks, and provides an approach that can be used to investigate other digital tasks. The detailed analysis of performance errors identified where soldiers had difficulty interpreting specific system interface cues, and also identified where training materials could be enhanced to stress common error avoidance and error recovery procedures. Detailed performance error information such as this could greatly aid training developers in prioritizing training revision and interface design needs. Research findings did not yield evidence of psychomotor skill decay for IVIS cursor tracking tasks. Training developers should continue to examine the training benefit and cost effectiveness of including the expensive full fidelity IVIS hand controller as part of the digital communications training system. The present research showed a significant relationship between the seven-item multiple choice test of IVIS procedures knowledge and hands-on task performance 30 days later. This finding suggests that digital skill retention might be enhanced by including written task knowledge testing as part of training.

DIGITAL PROCEDURAL SKILL RETENTION FOR SELECTED M1A2 TANK INTER-VEHICULAR INFORMATION SYSTEM (IVIS) TASKS

CONTENTS

CONTENTS (Continued)

CONTENTS (Continued)

LIST OF TABLES

LIST OF FIGURES

DIGITAL PROCEDURAL SKILL RETENTION FOR SELECTED M1A2 TANK INTER-VEHICULAR INFORMATION SYSTEM (IVIS) TASKS

Introduction

Requirement

The U.S. Army's Force XXI program will field smaller yet more lethal divisions where soldiers will make extensive use of digital communications technologies to speed the exchange of information among all operational levels. Along with the increased capabilities, the new systems can also place great demands on the soldier's ability to accurately remember and perform long sequences of step-by-step procedural tasks. Anecdotal reports from field trials and testing repeatedly indicate that the basic procedural skills needed to operate digital communications systems are highly perishable. High rates of skill decay could limit the Army's ability to employ this key communications technology, and could require a major investment in skill sustainment training. Army training developers need an accurate estimate of digital procedural skill retention for representative digital communications system tasks. They also need a performance assessment method that can provide the detailed diagnostic information necessary to build and refine both initial instruction and sustainment training programs.

Goal of the Present Research

The goal of the present research was to develop estimates of skill retention, and a performance error coding method, for representative digital communications system tasks using the M1A2 Abrams tank Inter-Vehicular Information System (IVIS). The term "skill" is used here to refer to a wide variety of complex, learned behaviors which typically require motor processes for goal attainment, while the term "retention" will refer to the maintenance of skills in the absence of practice (Schendel and Hagman, 1991). The IVIS tasks selected for evaluation were (1) create and send digital map overlays, and (2) create and send digital reports. The digital overlay and report tasks represent basic digital communications requirements that will be common across many current and future systems.

Training developers need an accurate picture of task skill requirements in order to efficiently match limited resources and training techniques to these demands. To meet this goal, the

present research investigated the contributions of procedural knowledge, declarative knowledge, and psychomotor skill to observed task success. Anectdotal estimates of digital skill decay are of limited value, as there is typically no record of initial skill proficiency, or any indication of whether the lost skills could be recovered. The present research goes beyond this limitation by providing initial skill acquisition estimates as a necessary prerequisite to the investigation of skill retention. Likewise, an estimate of skill recoverability was developed to identify how well soldiers could regain task proficiency with unaided practice. As a final goal of the present research, an error coding approach was introduced that identifies the specific location of recurring performance problems, demonstrating a performance measurement method that could greatly assist training developers in focusing training revision and equipment design efforts.

Concern Over Highly Perishable Digital Skills

The concern over the apparent rapid loss of digital skill has been well documented in military research, and in soldiers reports of their experience in field operations. In particular, experience with the M1A2 Abrams tank IVIS digital communications systems suggests that digital skills are highly perishable, and that research should be directed to identify and address initial and sustainment training needs. Recent ARI research conducted by Ford, Campbell, and Cobb (1998) investigated training issues associated with digitization, focusing on the M1A2 training program. The authors concluded that the skill decay characteristics of military tasks represents a research area with high potential for payback, stating that "If sustainment and retraining of tasks were based on known factors and conditions of decay and performance, the savings in training efficiencies would be significant."

Attending to both the advantages and risks associated with the move to digitization, Quinkert and Black (1994) state that modern information technology is a double edged sword that can greatly enhance and improve combat effectiveness or overload and cripple unit operations. The authors report that one of the key lessons learned from the 1994 Operation Desert Hammer Advanced Warfighting Experiment (AWE) was that digital skills were "higher order" in nature, perished easily, and required new training techniques which go beyond knowing how to push the right "procedural buttons". Looking at the total force, Salter and Black (1998) examined the training and sustainment of conventional or back-up skills for operations when digital

system capabilities become degraded. The authors conclude that skill retention will be a major issue as the digitized force accommodates the competing training time demands of new digital tasks, modified old tasks, and unmodified old tasks.

Reporting his personal observations on the state of digital systems training, the Master Gunner for 1st Cavalry Division described M1A2 skills as "exceptionally perishable" (Ryan & Iddins, 1999). Likewise, in the Operational Test and Evaluation Command (OPTEC) follow-on post fielding test for M1A2 (U.S. OPTEC, 1997), crews expressed the need for more sustainment training in the use of the IVIS communications system at the unit level, either through hands-on training with the real equipment, or through the use of an IVIS training device in garrison. Experience in AWEs Desert Hammer (U.S. Army Armor Center, 1994), and Focused Dispatch (Elliott, Sanders, & Quinkert, 1996) has established that soldiers can acquire the skills needed to operate the new generation of computer-based systems. However, the Focused Dispatch Final Report again concludes that "Digital skills are highly perishable" (U.S. Army Armor Center, 1996). This report states that to simply maintain digital proficiency long enough to complete the AWE requires that the unit have an extensive, resourced training period, and that these skills must be sustained throughout the AWE by continued training and stabilization. Here, the call is for training development specifically designed to address the initial and sustainment training demands of highly perishable digital skills.

Procedural Skill Retention

A number of task characteristics can be identified that may underlie the retention trends observed in Army field trials of digital communications systems. The performance of M1A2 IVIS overlay and report tasks involves procedural actions requiring sequential "step-by-step" thinking and discrete motor responses to complete each task. While the procedural responses themselves are usually easy to execute, it is deciding what responses to make and in what sequence that pose the main problems for the learner (Schendel and Hagman, 1991). This description of procedural tasks is quite useful in suggesting that skill retention research needs to attend to both cognitive and psychomotor contributions to performance, and that the specific characteristics of a task that facilitate response selection and sequencing can enhance retention.

Cognitive and psychomotor factors. Cognitive contributions to task performance and skill retention can be examined in terms of procedural and declarative knowledge requirements. Procedural knowledge has been described as knowing how to execute the procedures necessary to perform a given task (many of which have become more rapid and automatic through practice), such as how to use a typewriter by touch, operate a computer, or disassemble and reassemble a rifle (Druckman & Bjork, 1991). The ability to rapidly perform a short sequence of IVIS menu option selections without consciously having to think through each step might reflect procedural knowledge. Retention of procedural knowledge is typically measured by the extent to which task procedures can be demonstrated through hands-on performance, rather than by the extent to which they can be recalled.

In contrast to procedural knowledge, declarative knowledge is described as the knowledge of facts or static information, and is often measured by tests of recall. In the case of M1A2 IVIS declarative knowledge might include the knowledge of menu organization and rules associated with interface features required to send overlays and reports. This contrast between procedural and declarative knowledge is relevant to the present investigation of digital procedural skill decay. Declarative knowledge represents a deeper level of knowledge integration, often associated with long term memory, than procedural knowledge. Research has shown that the level of knowledge to which tasks are initially trained (procedural vs. declarative) can be a predictor of long term skill retention (Druckman & Bjork, 1991).

Skilled performance will typically require some element of psychomotor skill for goal attainment, such as moving levers, or pushing buttons. In the case of the M1A2 IVIS, tasks are composed of a series of discrete motor responses with a distinct beginning and end, such as pushing menu option buttons, or using a thumb controller to move a cursor to a specific location on a map display. While Schendel and Hagman (1991) have stated that the psychomotor skill component of procedural tasks is often minimal, the investigation of digital procedural skill retention should include an assessment of how well soldiers are able to acquire and retain this essential skill.

Task characteristics. The specific characteristics of a task that facilitate response selection and sequencing can greatly impact skill requirements, and thus retention of task proficiency. Digital system tasks differ in their structure

from more traditional tasks and may present different training demands. Traditional mechanical systems typically present the operator with continuous motor tasks which logically flow from one to the next and are thus resistant to forgetting. In contrast, modern digital system tasks will often require an operator to perform a series of discrete procedural steps, such as computer menu options navigation, which researchers have found to be more susceptible to degradation (Mengelkoch, Adams & Gainer, 1971).

A review of the literature specifically addressing the training of computer skills (Throne & Lickteig, 1997) also suggests that the tasks associated with the new generation of Army digital systems may require skills that are highly perishable. As an example, examining the skill decay issue in a military context, research has previously found that the number of procedural steps in a task served as the best predictor of skill degradation (Shields, Goldberg & Dressel, 1979). While not directly measuring skill retention over time, evidence from the Combat Vehicle Command and Control (CVC2) research program (Du Bois & Smith, 1991) also suggested that there might be a rapid decay of skills required for the operation of the M1A2 IVIS equipment.

A number of task characteristics identified in retention research have been incorporated into the predictive model of procedural skill retention developed by Rose, Czarnolewski, Gragg, Austin, Ford, Doyle, and Hagman (1985). Task characteristics incorporated in the model include procedure cueing, psychomotor requirements, number of procedural steps, and mental processing requirements. The model provides a ten-characteristic task rating method, the User's Decision Aid, which allows the trainer to estimate task proficiency levels at a particular time and project the rate of proficiency loss over a 12-month retention interval. The User's Decision Aid was developed from, and validated against, actual retention data collected from soldiers serving in several Military Occupational Specialty (MOS) areas (63N, 11B, and 13B). While the rating scale was developed as a retention prediction tool, it might also assist equipment and training developers in identifying characteristics of tasks that might represent skill retention risks, and the means to reduce these risks.

M1A2 Abrams Tank IVIS

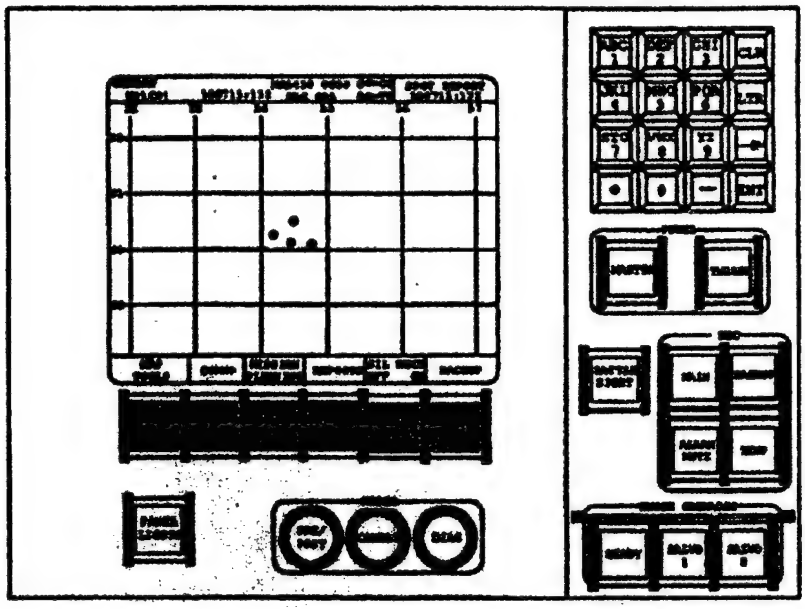
Having considered dimensions of knowledge and task characteristics as potential contributors to skill retention,

the specific equipment and training associated with the M1A2 IVIS can be reviewed. The IVIS is a digital communications system developed originally as a battalion level asset. The IVIS improves command and control capabilities by constantly exchanging and updating position location/navigation data with other friendly users. The IVIS provides the M1A2 tank commander with the capability for digital transmission of reports and overlays between vehicles. IVIS is a software based system implemented in the Commander's Integrated Display (see Figure 1). The IVIS uses a radio interface unit coupled to the Single Channel Ground/Airborne Radio System (SINCGARS) to transmit and receive digital messages. The IVIS tactical display is a 5 X 6 inch monochrome (black and orange) screen, and serves as the commander's primary interface with IVIS. The IVIS operator navigates through software menu options and enters data to create overlays and reports using multifunction keys, screen menus, a multifunction keypad, and the Commander's Control Handle Assembly (CCHA) cursor controller. The IVIS formatted reports include Contact, Spot, Call For Fire, medical evacuation (MEDEVAC) reports, and others. The IVIS overlays include Operations 1, Operations 2, Fire Support, Enemy, Obstacle overlays, and overlay updates. The IVIS also provides data for display of mutual position/navigation information. Every 15 minutes or 100 meters of tank movement IVIS automatically generates a position report that is transmitted to other tanks on the IVIS net (U.S. Department of the Army, 1995).

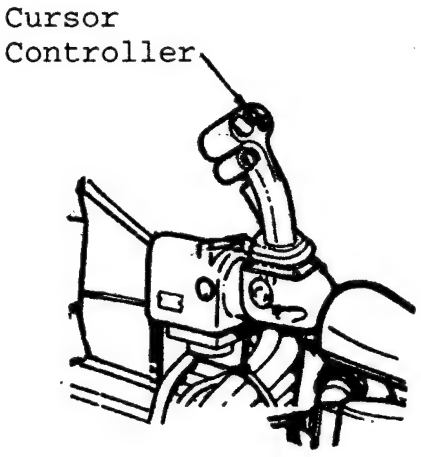
Formal instruction on operating procedures for the IVIS is typically provided as part of training for soldiers transitioning from M1A1 to M1A2. The current IVIS training is provided by a New Equipment Training Team (NETT) consisting of military instructors and contractor personnel in a classroom environment using Crew Station Trainers (CSTs). The CSTs are computer workstations that provide all the screens and menus required to teach the student selected M1A2 tank systems. Soldiers participate in a four-hour block of instruction on IVIS mission planning features, and a four-hour block of instruction on how to create and send reports. After this classroom training soldiers are expected to maintain proficiency on IVIS through hands-on practice at the unit.

Issues Guiding Research Design

The present evaluation of digital procedural skill retention was designed to address several issues. Original level of learning was identified by measuring task performance



IVIS Display and Controls



Commanders Control
Handle Assembly (CCHA)

Figure 1. The IVIS and CCHA. Illustrations from Operator's Manual, Operator Controls, PMCS, and Operation Under Usual Conditions, Tank, Combat, Full-Tracked: 120-MM gun, M1A2 (TM 9-2350-288-10-1), U.S. Army Tank-Automotive and Armaments Command, Warren, MI., 1995, p. 1-73.

at the conclusion of training. Task organization was controlled by following the structure and content of the M1A2 Abrams tank NETT lesson plan, and a 30 day retention span between task performance assessment was applied to all participants. The IVIS overlay and report tasks were selected based on their "real world" features, and generalizability to other digital communication system requirements. Self-report assessments were made of participants skill and knowledge (particularly with respect to computer skills), motivation, and several biographical factors such as rank and education. In addition to the primary measures of procedural skills, measures of declarative knowledge, and psychomotor skills were incorporated to capture cognitive, skill-based, and affective components of performance.

Research Objectives

The present research was designed to provide estimates of procedural skill retention, and a performance error coding method, for a representative digital communications system (M1A2 IVIS). While there have been numerous reports from field

testing and field experiments describing digital skill decay, these reports are anecdotal and cannot account for differences in initial training, time since training, tasks performed, and performance criteria. Based on issues identified in the research literature, an assessment of IVIS interface psychomotor skill retention and the retention of declarative knowledge of IVIS tasks were also conducted. The research objectives were met by addressing the six central issues identified in Table 1.

Table 1

Central Research Issues

1. Digital skill acquisition: Estimate IVIS procedural skill acquisition during initial train-up.
2. Digital skill retention: Estimate IVIS procedural skill retention and recovery 30 days after training.
3. Digital skill subtasks: Determine whether IVIS procedural subtasks can provide diagnostic information to facilitate performance measurement, feedback, and training development.
4. Digital skill task steps: Determine whether error patterns on IVIS task steps can provide diagnostic information to enhance performance measurement, feedback, and training development.
5. Psychomotor skill: Estimate the amount of psychomotor skill learning that occurs during train-up, and the retention and recovery of this skill 30 days after training.
6. Declarative knowledge: Estimate the amount of IVIS procedure declarative knowledge learning that occurs during train-up, and the retention and recovery of this skill 30 days after training.

Method

Participants

Twenty-eight soldiers qualified in MOS 19K (Tank Crewman) participated in the study. The ranks of the participants included 8 E-2, 4 E-3, 12 E-4, 5 E-5, and 1 E-6. All soldiers

were assigned to Fort Knox at the time of the study, in either 1st Squadron, 16th Cavalry Regiment, or 1st and 2nd Battalions, 81st Regiment, 1st Armored Training Brigade.

Equipment

All training and evaluation sessions were conducted at the Fort Knox Mounted Warfare Testbed. A research area 15 X 19 feet in size was established with portable wall partitions to enclose the four CST workstations and associated equipment. Four CST workstations produced by General Dynamics Land Systems Division were used for training and evaluation. The CST consists of a SUN SPARC desk-top computer running version 2.5a M1A2 IVIS software, 20" color touchscreen monitor, keyboard, mouse, and CCHA (see Figure 2). The CCHA incorporates a thumb lever used to control cursor movement. The mouse and keyboard were not used in the evaluation. Each CST was located on a separate 30" by 60" table where three soldiers and the instructor performed tasks.

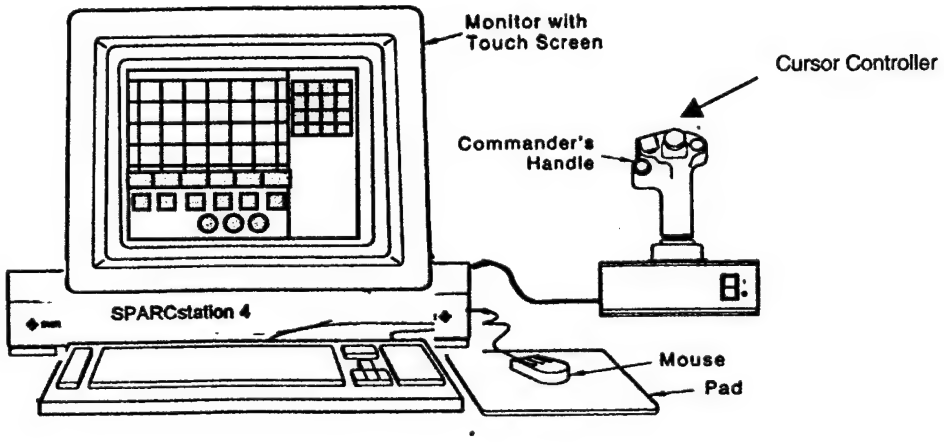


Figure 2. Crew Station Trainer. Illustration from M1A2 Crew Station Trainer (CST) User's Manual, General Dynamics Land Systems Division, Warren, MI., (1997), p.2.

Three CSTs were set up as student stations with video recording equipment to capture student task performance. The CST screen information presents all IVIS button pushes and menu item selections, as buttons and menu items are highlighted or change values when selected. A constant readout of time (hours, minutes, and seconds) appears at the top of the IVIS screen and was also recorded. Video recording equipment at each student station included a VHS format video cassette recorder model BR-3200, a color monitor model CVM-1271, and a scan converter to

allow the SUN SPARC monitor signal to be recorded in VHS format, providing a permanent record of actions for data analysis. One CST was set up as the instructor station. This station had an overhead projector connected to the CST so that the instructor could demonstrate IVIS procedures to students by projecting his computer screen display onto a screen at the front of the training area. A combination VCR and monitor with remote control was used for video data reduction.

Materials

Video Data Reduction Sheets were prepared to record performance on IVIS overlay and report tasks (see Appendix B). The sheets were designed to record overall task success and performance time, and task step success. The Overlay Video Data Reduction Sheet included four entry blanks used to record times for Overlay subtasks. Twenty-three task steps were identified for the IVIS overlay tasks, and 19 task steps were identified for the IVIS report tasks. Identification of task steps was based on a review of the procedures outlined in the NETT lesson plan, and the specific requirements of the experimental tasks. A separate Video Data Reduction Sheet was prepared for each of the 14 experimental tasks, and annotated with the specific information requirements for that task, such as type of graphic to be created, and location. The data sheets included a space for experimenter comments, which was used to record participant task performance that did not conform to the required task step sequence.

Three versions of an IVIS System Procedures Review questionnaire were prepared (see Appendix C) for administration at different points in the training and evaluation schedule. Each questionnaire first presented ten questions addressing IVIS overlay and report task knowledge. Seven of the 10 questions address task knowledge required to perform the experimental tasks (questions 1, 2, 4, 7, 8, 9, 10), while three questions address task knowledge presented in training but not required for experimental task performance. Each questionnaire contained additional questions asking for specific information such as predictions of future performance, and reports of practice on IVIS tasks, that were relevant at particular points in the experiment evaluation sequence. The IVIS System Procedures Review 1 included questions addressing training adequacy, and the soldier's estimate of his ability to perform IVIS tasks on Day 30. The IVIS System Procedures Review 2 included questions addressing training adequacy, motivation, and whether the soldier practiced tasks during the 30 day retention period. The

IVIS System Procedures Review 3 included two questions on the adequacy of training in addition to the basic set of ten IVIS task knowledge questions.

IVIS CST Exercises

IVIS task cards. Fourteen experimental tasks were created to evaluate soldiers skills in creating and sending IVIS overlays and reports. Experimental tasks were based on training content taken from the M1A2 NETT lesson plan "Mission Planning" (U.S. Army Armor Center and School, 1997), and the lesson plan "Prepare, Send, and Respond to Reports" (U.S. Army Armor Center and School, 1996a). Information describing each experimental task was printed on a 5" X 7" index card for use by participants during the experiment. Eight IVIS overlay experimental tasks were created which required the soldiers to create and send an overlay with a multiple point graphic, a Target Reference Point (TRP), and a six character graphic label. Six IVIS report experimental tasks were prepared which required the soldiers to create and send a report with a target coordinate, two targets (including target subtype and number), Friendly Action, and Enemy Activity information. A description of content for the eight overlay tasks is provided as Appendix D. A description of the content for the six report tasks is provided as Appendix E. An example of an IVIS overlay task card (reduced in size) is provided as Figure 3. An example of an IVIS report task card is provided as Figure 4.

UPDATE AND SEND OBSTACLE OVERLAY
Update and send your Obstacle Overlay with the following information to your CO CMDR

Using the **THUMB CURSOR** insert a MINEFIELD graphic
- Coord 1: 2400 2550
- Coord 2: 2400 2500

Using the **IVIS KEYPAD** insert a TARGET REFERENCE POINT graphic
- Coord: 2300 2750
- Label: AA0001

PRESS THE DIAG MODE BUTTON WHEN DONE (B1A3)

Figure 3. IVIS Overlay task card.

SEND SPOT REPORT

Report to your CO CMDR that you see 2 BMP armored personnel carriers and 4 T72 tanks. Using **THUMB CURSOR** enter target grid location 16R ES 2650 2500. Report that the enemy is withdrawing and you are continuing with your mission.

PRESS THE DIAG MODE BUTTON WHEN DONE (A2B4)

Figure 4. IVIS Report task card.

Criteria for scoring trials as successful. The criteria for successful task completion were developed to match the requirements for sending an accurate IVIS message in a tactical environment. No performance time criteria for task success were established for the IVIS overlay and report tasks, due in part to the absence of performance time criteria in the M1A2 NETT lesson plan. The decision not to introduce a performance time standard was also made so that soldiers would be less likely to give up on a task during the Day 1 evaluation, and so that Day 30 task performance would better reflect soldiers ability to recover skills by working through the tasks. Specific requirements for each task to be judged successful are provided as Appendix F.

Procedure

All soldiers attended a train-up and evaluation session (Day 1), and returned for a follow-on evaluation of IVIS skills 30 days later (Day 30). An outline of Day 1 and Day 30 training and evaluation events is provided as Table 2. The researcher first described the capabilities of the M1A2 tank IVIS system, and provided basic instruction on map overlays, and the use of the eight-digit Military Grid Reference System (MGRS) to find the location of points on the IVIS map display (see Appendix G). Soldiers next received a one-hour introduction to IVIS screen information, menu structure, and the keypad and CCHA interface.

This was followed by a one-hour block of instruction on IVIS reports, and a two-hour block of instruction on IVIS overlays.

Table 2

Schedule Of Experiment Events

Day 1 Session Events
1. Privacy Act Statement
2. Introduction and MGRS basics
3. Demographic Survey
4. Training: IVIS screen information and interface
5. Psychomotor skill evaluation 1
6. Training: IVIS reports and overlays
7. Digital Skills Training Factors (motivation) questionnaire
8. Participants perform seven IVIS tasks
Task 1: Overlay
Task 2: Report
Task 3: Overlay
Task 4: Report
Task 5: Overlay
Task 6: Report
Task 7: Overlay
9. Psychomotor skill evaluation 2
10. IVIS System Procedures Review 1 (task knowledge)
Break for 30 days
Day 30 Session Events
11. Introduction and MGRS basics
12. IVIS System Procedures Review 2 (task knowledge)
13. Psychomotor skill evaluation 3
14. Participants perform seven IVIS tasks
Task 1: Overlay
Task 2: Report
Task 3: Overlay
Task 4: Report
Task 5: Overlay
Task 6: Report
Task 7: Overlay
15. Psychomotor skill evaluation 4
16. IVIS System Procedures Review 3 (task knowledge)

The IVIS report and overlay task training required soldiers to create and send reports and overlays with information and graphics that would later appear in the experimental tasks. Overlay and Report instruction included one practice trial using data presented on the 3" X 5" IVIS task cards to familiarize soldiers with the way information was formatted on the experimental task. Soldiers were encouraged to ask questions to ensure that they understood the task requirements presented on the card. The IVIS training closely followed the organization and content of the M1A2 NETT lesson plan materials for mission planning, and creating and sending reports (M1A2 New Equipment Training Team (NETT) lesson plan "Mission Planning" (U.S. Army Armor Center and School, 1997), and the lesson plan "Prepare, Send, and Respond to Reports" (U.S. Army Armor Center and School, 1996a). The hands-on training lecture was delivered by a former Army IVIS instructor with three years experience training soldiers on the use of the IVIS system.

Prior to beginning the set of seven tasks on Day 1 and Day 30 the researchers read the following statement to provide a set of performance criteria for the experiment: "Report accurate information as quickly as possible. First priority is accuracy. Perform the task as quickly as you can without making errors." This standard was based on information contained in Fort Knox Tank Platoon Standard Operating Procedure (SOP) Report Guidelines (FKSM 17-15-3, 1996b). The desire was to have soldiers complete all tasks start to finish, and that soldiers not give up because they perceived that a task had taken too long to perform.

Immediately following the Day 1 instruction, soldiers performed seven IVIS tasks. Because evaluation trials also serve to provide the soldier with practice that can improve task performance, the number and alternating sequence of overlay and report evaluation trials had to be strictly controlled. Soldiers returned to the test site 30 days later for a follow-on evaluation of IVIS skills and again performed seven IVIS report and overlay tasks. Soldiers performed eight IVIS overlay tasks and six IVIS report tasks in total. The unequal number of tasks was chosen so that an overlay task would be the first and last trial in both train-up Day 1 and follow-on evaluation Day 30. In this way a direct comparison could be made between IVIS overlay task performance on the last Day 1 overlay task, and the first Day 30 overlay task. The assignment of IVIS overlay and report tasks within the alternating sequence of tasks was counter-balanced using a Latin Squares design. Questionnaires were administered to assess soldier knowledge of IVIS

procedures, and motivation. A digit tracking task was administered four times to assess soldier psychomotor skills. The tracking task required soldiers to use the CCHA to click on and highlight ten numbers in sequence that were presented on the CST screen. The pattern and sequence of the ten numbers are provided in Appendix H.

Demographic Measures

All soldiers completed a demographic questionnaire. The demographic measures included: Rank/Grade, age, time in the military, duty position, experience with computers, and highest level of civilian education. The demographic questionnaire and summary of the responses are provided as Appendix I and J respectively. One soldier was reassigned after completing Day 1 training and evaluation, and did not return for the Day 30 evaluation.

Performance Estimation

Performance estimates. In making estimates of skill decay it was first necessary to establish that soldiers were initially trained to proficiency on Day 1. The criteria for overlay skill acquisition was set at successful completion of at least three of the four overlay tasks. Criteria for report skill acquisition was set as successful completion of at least two of the three report tasks. One estimate of learning, three estimates of skill retention, and one estimate of skill recovery were developed:

- Learning: A comparison of performance on First and Last Day 1 trials provided an estimate of skill improvement with hands-on practice immediately after the training lectures.

- Retention (no practice): A comparison of performance on the Last Day 1 and First Day 30 trials provided an estimate of skill retention over 30 days without practice.

- Retention (with practice): A comparison of performance on the Last Day 1 and Last Day 30 trials provided an estimate of skill retention after the soldier had additional practice completing the evaluation trials on Day 30.

- Retention (skill acquisition criteria): Application of the Day 1 criteria for skill acquisition to Day 30 performance. Retention of Overlay Skilled status required successful completion of at least three of the four Day 30 overlay tasks.

Criteria for retention of Report Skilled status required successful completion of at least two of the three Day 30 report tasks. This estimate is only appropriate for procedural skill assessment, and does not apply to declarative or psychomotor skills.

- Recovery: A comparison of performance on the First Day 30 Trial and Last Day 30 Trials provided an estimate of performance improvement across the seven Day 30 evaluation trials.

Performance data. The principal performance data for this research were task accuracy and task completion time. Task accuracy was analyzed at three levels of detail: overall task success, subtask success, and individual task step success based on a review of Video Data Reduction Sheets information. Times were recorded for overall task completion, and also for IVIS overlay sub-task performance. Report subtask times were not recorded as soldiers frequently performed subtasks out of sequence, and several subtasks typically involved very short performance times.

The primary source of procedural performance data for the overlay and reports tasks was the videotaped "screen capture" record of soldier button pushes and cursor movement used to perform each task. The clock component of the IVIS screen recording provided a continuously running record of task performance time in hours, minutes, and seconds. The author and principle instructor served as video data reducers, viewing each tape recorded performance trial, and recording time data and performance actions using Video Data Reduction Sheets developed for this purpose (see Appendix B). Performance times and task performance actions scoring required the agreement of both video data reducers.

Statistical analysis. The present experiment followed a pair-wise comparisons approach between selected Day 1 and Day 30 trial success rates. Given the binomial Go/No Go nature of the task success data, a test for correlated proportions (McNemar, 1975) was used to compare selected Day 1 and Day 30 trials. Paired-samples t-tests were used for task performance time comparisons, and psychomotor trial time comparisons, with alpha set at 0.05.

Sample size power estimation. The number of soldiers required for the experiment was estimated based on power estimates for task performance time paired t-test comparisons.

Boldovici and Kolasinski (1997) identify 0.80 as the commonly accepted value for power, and point out that by choosing to detect a test-retest performance time difference equal in size to one standard deviation in performance time, the critical test statistic "d" has a value of 1. With a = 0.05, d = 1.00, power = 0.80, n (troop support) = 17. Twenty-seven overlay task trials were performed over a period of several months while refining the experimental tasks. Analysis of these early trials yielded a mean performance time of 167.22 seconds for overlay tasks, with a standard deviation of 70.36 seconds. A time value equal to the standard deviation was accepted as a reasonable performance effect to detect in comparing overlay trials.

Results

Results Overview

IVIS Overlay procedural skill retention. The central findings for the present research are summarized in Table 3. On Day 1, 22 soldiers successfully completed three or more of the four overlay tasks. This group constituted the 100 percent Overlay Skilled sample for follow-on evaluations of skill retention. On Day 30 only 48 percent of the Overlay Skilled group was able to successfully complete three or more of the four overlay trials, representing a significant 52 percent reduction in the proportion of Overlay Skilled soldiers after 30 days.

The comparison of success rates on individual trials provided evidence that overlay task performance decreased significantly over the 30 day retention interval and was not recovered with practice on Day 30. The proportion of Overlay Skilled soldiers successfully completing overlay tasks dropped significantly from 86 percent on the Last Day 1 trial to only 29 percent on the First Day 30 trial (a decrease of 57 percentage points). On the final Day 30 trial the overlay task success rate had only risen to 48 percent, so that a significant 38 percentage point decrease in skills remained compared to the Last Day 1 trial success rate of 86 percent.

The comparison of overlay performance times for successful trials revealed significant improvement across Day 1 trials, with performance times decreasing an average of 34 seconds from first to last trial. The significant drop in performance time provided evidence of continued learning with practice on Day 1, after the formal training lecture had been completed. Overlay mean performance time increased by 321 seconds across the 30 day

retention interval providing evidence of significant skill decay. Day 30 trials performance time did show significant recovery of skill with practice, with mean time to perform tasks decreasing by 315 seconds. Across Day 30 Overlay trials performance times decreased to the point where there was no evidence that Last Day 30 trial times differed significantly from the Last Day 1 times.

Table 3

Summary of Digital Skill Retention Comparisons

Skill Criteria	Retention Without Practice (Last Day 1 vs. First Day 30)	Retention With Practice (Last Day 1 vs. Last Day 30)
Overlay Task Success Rate	57%*** Lower	38%* Lower
Overlay Task Performance Time	321* Seconds slower	No significant difference
Overlay Skilled Criteria	Not applicable	52%*** Fewer skilled
Report Task Success Rate	No significant difference	No significant difference
Report Task Performance Time	52*** Seconds slower	No significant difference
Report Skilled Criteria	Not applicable	23%** Fewer skilled
Psychomotor Task Time	No significant difference	No significant difference
Declarative Knowledge Score	29%*** Lower test score	No significant difference

Note. Overlay results are for the Overlay Skilled sample, Day 1 n = 22, Day 30 n = 21. Report results are for the Report Skilled sample, Day 1 n = 23, Day 30 n = 22.
* $p < .05$. ** $p < .01$. *** $p < .001$.

IVIS Report procedural skill retention. On Day 1, 23 soldiers successfully completed two or more of the three report tasks. This group constituted the 100 percent Report Skilled sample for follow-on evaluations of skill retention. On Day 30 only 77 percent of the Report Skilled group was able to successfully complete two or more of the three report trials, representing a significant 23 percent reduction in the proportion of Overlay Skilled soldiers after thirty days. The comparison of success rates for individual trials failed to provide evidence of additional skill learning on Day 1 after training, or of skill recovery on Day 30 after completing the evaluation trials.

In contrast to the task success criteria, the task time criteria did reveal a significant 46 second improvement with practice (learning) across Day 1 trials. Also, while report success rate did not reveal skill decay across the 30 day retention interval, the significant 52 second increase in report performance time did provide evidence of skill decay across the retention interval. Across Day 30 trials performance times decreased to the point where there was no evidence that Last Day 30 report trial times differed significantly from the Last Day 1 times.

IVIS Psychomotor skill retention. Performance times for the psychomotor number tracking task showed a significant 23 second improvement across Day 1 trials. This finding provided evidence that soldiers made significant improvement in their use of the CCHA cursor controller with practice during the seven Day 1 trials. The time required to complete the number tracking task increased by only three seconds over the 30 day retention interval which failed to provide evidence of significant skill decay. The five second improvement in performance time across Day 30 trials was small, but did provide evidence of statistically significant skill recovery. After this recovery, there was no evidence that Last Day 30 psychomotor trial times differed significantly from the Last Day 1 times.

IVIS Declarative knowledge retention. Declarative knowledge test scores showed a significant 1.86 point (29%) decrease across the 30 day retention interval, followed by a significant 1.52 point (24%) improvement over Day 30 trials. The comparison of Last Day 1 and Last Day 30 test scores failed to provide evidence of lasting decay in soldiers declarative knowledge of IVIS overlay and report tasks after the 30 day retention interval.

The remainder of the results section presents a detailed review of the findings for each of the six research issues identified previously in Table 1. The six issues address Day 1 skill acquisition, Day 30 skill retention, IVIS subtask performance, IVIS task step performance, psychomotor skill, and declarative knowledge skill.

Issue 1. Digital Skill Acquisition

The issue of IVIS skill retention could not be addressed without first determining whether skills had been acquired during the Day 1 train-up and evaluation session. Not all participants learned how to perform IVIS tasks on Day 1. It would confound estimates of skills retention to measure their performance again on Day 30 and attribute low performance to skill decay, rather than the failure to acquire the skills in the first place. Therefore, those who failed to acquire skills on Day 1 were identified and eliminated from the sample when estimating skill decay over the 30 day retention interval.

Criteria for IVIS skill acquisition. Summary tables of overlay and report trial success rate and performance times for all soldiers and all trials are provided as Appendix K and L, respectively. Table 4 presents the number of Day 1 training session overlay and report tasks that soldiers performed correctly. From the distribution of scores it was decided to select those participants who successfully completed three or more of the four overlay tasks as having successfully acquired the overlay skills, so that the criteria for IVIS skills acquisition was a 75% or better success rate on Day 1 tasks. Using this criteria 22 of the participants (78.5%) were judged to have acquired IVIS overlay skill on Day 1, and were referred to as the Overlay Skilled group. In responding to IVIS System Procedures Review 1 soldiers rated the training provided for overlays as "Very Adequate" (89%) or Fairly Adequate (11%), and the training provided for reports as "Very Adequate" (93%) or "Fairly Adequate" (7%).

Table 4 also presents the number of Day 1 training session report tasks performed correctly. From the distribution of scores it was decided to select those who successfully completed two or more of the three report tasks as having successfully acquired the reports skill, so that the criteria for acquisition was a 66% success rate or better. Using this criteria for report skill acquisition, 23 participants (82%) were judged to have acquired IVIS report skills on Day 1, and were referred to as the Report Skilled group. One soldier was transferred after

the Day 1 evaluations, reducing the Day 30 sample size to 27, with 21 soldiers remaining from the Overlay Skilled group, and 22 remaining from the Report Skilled group.

Table 4

Number of Soldiers Successfully Completing Day 1 Trials

Successful Trials	Overlay Number (percent)	Report Number (percent)
0	4 (14)	2 (7)
1	0 (0)	3 (11)
2	2 (7)	9 (32)
3	13 (46)	14 (50)
4	9 (33)	
Total	28 (100)	28 (100)

Note. There were four overlay and three report Day 1 trials.

The criteria for IVIS overlay skill acquisition (75%) differed from the criteria for reports (66%) due to the different number of tasks performed, so that a direct comparison of acquisition rates was not possible. The proportion of overlay tasks successfully completed for the Skill Acquired, and Not Acquired groups is provided as Figure 5. The figure suggests that soldiers that did not acquire skills have low success rates in both the Day 1 and Day 30 evaluations.

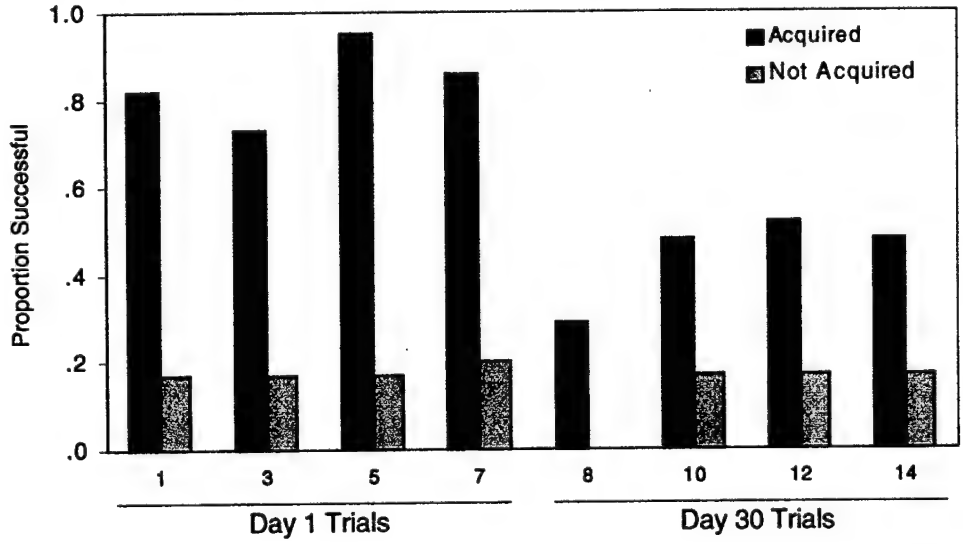


Figure 5. Soldiers successfully completing overlay tasks.

The proportion of report tasks successfully completed for the Skill Acquired, and Not Acquired groups is provided as Figure 6. The figure suggests that soldiers that did not acquire report skills have low success rates in both the Day 1 and Day 30 evaluations compared to the skilled group.

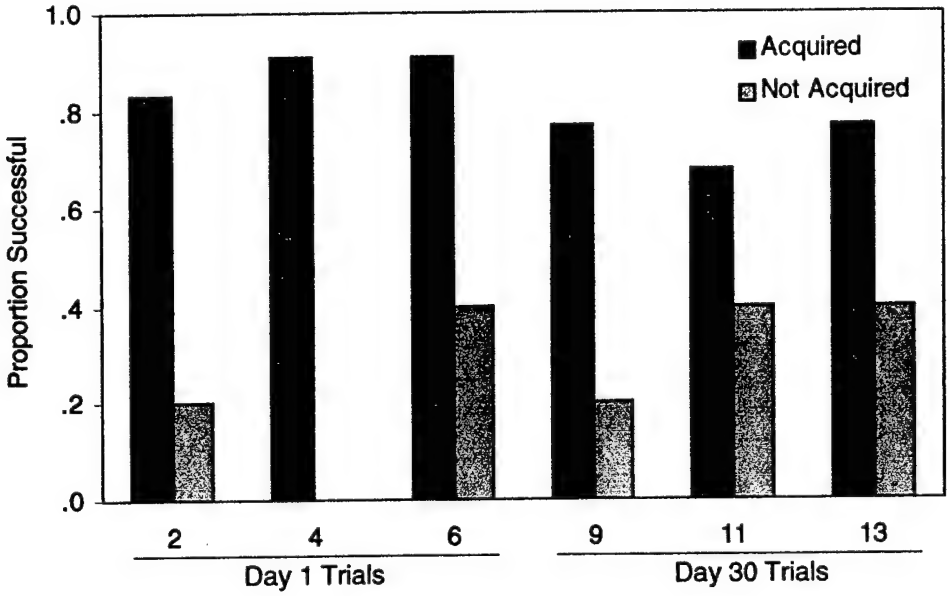


Figure 6. Soldiers successfully completing report tasks.

The performance time and success rate data for IVIS overlay and report trials for the Skilled Groups are provided as Appendix M and N respectively. It should be noted that the task performance times include times for successful tasks only. For some tasks there were very few successful trials, resulting in very little time data. As an example, only six participants successfully completed Overlay Trial 8, which immediately follows the 30 day delay period. An outlier analysis was conducted to identify extreme performance time values falling more than three standard deviations beyond the mean for a particular trial. The total data set included 385 time values (7 trials per day, with 28 Day 1 and 27 Day 30 soldiers). From the total of 385 time values, five outlier values (one overlay, four report) were identified using the three standard deviation criteria. For each outlier value a "Winsorizing" procedure suggested by Marascuilo and McSweeney (1977) was applied where the largest (outlier) time value was replaced with the next largest value, and the smallest time value was also replaced with the next smallest value.

One IVIS instructor served as a subject matter expert (SME) for the experiment, and provided task performance times that appear as a benchmark reference in overlay and report performance time figures. The SME performed four overlay and three report using experimental materials, and following experimental procedures. The SME was instructed to perform the tasks at a pace that would be appropriate for an operational environment. The mean times for successful task completion were 150 seconds for overlays, and 78 seconds for reports.

Perceived training adequacy. Questions presented in IVIS System Procedures Review 1 asked soldiers to rate the quality of the experiment training they had received on Day 1. Soldiers rated the training for overlay tasks as "Very Adequate" (89%), and "Fairly Adequate" (11%), and rated report task training as "Very Adequate" (93%) and "Fairly Adequate" (7%). These findings provide some evidence that soldiers perceived the IVIS training as having adequately prepared them to perform the experimental tasks.

Issue 2. Digital Skill Retention

IVIS Overlay skill retention: successful task performance. Figure 7 presents the proportion of Overlay Skilled soldiers successfully completing Day 1 and Day 30 overlay tasks. Appendix O provides the summary results of statistical comparisons of overlay trial success rates using the McNemar test for correlated proportions with exact (one-tailed) binomial estimate (McNemar, 1975).

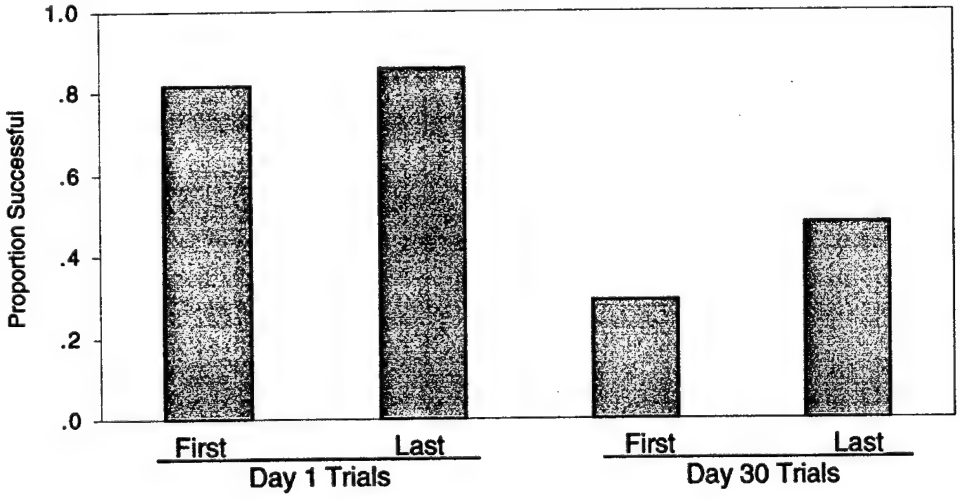


Figure 7. Proportion of Overlay Skilled soldiers successfully completing overlays for comparison trials.

Considering first the issue of learning during Day 1 trials, overlay task performance showed only slight improvement across tasks. The comparison of the proportion of soldiers successful on First Day 1 ($\underline{P}$ = .82) and Last Day 1 trials ($\underline{P}$ = 0.86) yields a difference of only .04, which was not significant. With a = .05, $\underline{n}$ = 22, power = .09, so that there is only a .09 probability that the test would find a significant difference of this size if it existed.

Examining skill retention after 30 days and prior to practice on all seven Day 30 trials, the comparison of Day 1 and Day 30 overlay task success rates provides evidence of significant skill decay over time. The decrease in task success from Last Day 1 ($\underline{P}$ = .86) to First Day 30 ($\underline{P}$ = .29) yielded a difference of .57 which was significant, $\underline{n}$ = 21, $\underline{p}$ = .001, power = .98. This finding suggests that participants experienced significant overlay skill decay over the 30 day retention period.

Considering skill retention after 30 days, and after practice with the seven Day 30 tasks, the 0.38 success rate decrease from Last Day 1 ($\underline{P}$ = .86) to Last Day 30 ($\underline{P}$ = .48) is also significant $\underline{n}$ = 21, $\underline{p}$ = .029, power = .74. This comparison provides evidence that skills were not recovered with practice on Day 30 tasks to the level of Day 1 performance.

As a final estimate of retention, the overlay skill acquisition criteria of three or more successful trials was applied to Day 30 task performance to identify those soldiers who remained Overlay Skilled. An advantage associated with comparisons based on this criteria was that it incorporated performance data from all eight overlay trials, as opposed to single trial retention comparisons. On Day 30 overlay trials 10 out of 21 Overlay Skilled soldiers successfully completed three or more tasks and again met the overlay skill acquisition criteria, while 11 Overlay Skilled soldiers failed to achieve this criteria for proficiency. Using the McNemar test with exact significance (1-tailed) binomial estimate (McNemar, 1975), the .52 decline in the proportion of soldiers meeting the Overlay Skilled criteria from the Day 1 ($\underline{P}$ = 1.00) to Day 30 ($\underline{P}$ = .48) was significant, $\underline{n}$ = 21, $\underline{p}$ = 0.000, power = 1.00, and provided further evidence of decay in overlay skill over the 30 day retention period.

Examining overlay skill recovery with practice during the Day 30 trials, the change in success rate from the First Day 30 ($\underline{P}$ = .29) to the Last Day 30 ($\underline{P}$ = .48) trials yields a

difference of .19, which was not significant. With a = .05, n = 21, power = .53. No statistically significant differences were found between the compared trials success rates to provide information about skill recovery on Day 30 as resulting from practice on the tasks.

IVIS Report skill retention: successful task performance. There are important differences between the sequencing of overlay and report tasks which must be considered in reviewing these results. The first and last trials for both Day 1 and Day 30 are overlay trials, so the participant receives one overlay task trial after the last report task on Day 1, and one overlay task trial before performing the first report task on Day 30. The intervention of two overlay tasks between the Last Day 1 and First Day 30 report comparisons provides extra practice which could result in a biased estimate of report skill retention over the 30 day delay. Here the intervening overlay tasks might provide general IVIS practice reminding the soldier how to do reports (a positive bias), or they might produce specific procedural confusion interfering with report performance (a negative bias).

The proportion of Report Skilled soldiers successfully completing First and Last Day 1 and Day 30 trials is presented in Figure 8. Appendix P provides the summary results of statistical comparisons of trial success rates using the McNemar test for correlated proportions with exact significance (1-tailed) binomial estimate (McNemar, 1975).

Looking first at Day 1 learning, there was a slight increase of .08 in success rate from First Day 1 (P = .83) to Last Day 1 (P = .91) trials which was not significant. With a = .05, n = 22, power = .09. For this small difference power is extremely low, and no statically significant differences associated with learning were found between the compared trials success rates.

Examining the retention of report skill over the 30 day retention interval, and without practice on the seven Day 30 tasks, the .14 decline in success from Last Day 1 (P = .91) to First Day 30 (P = .77) trials was not significant. With a = .05 , n = 21, power = .18, so that there is only a .18 probability that the test would find an effect of this size if it exists. No statically significant differences were found between the proportion of soldiers successful on the compared trials to provide information about skill decay over the 30 day interval.

Considering report skill retention after soldiers completed all seven Day 30 trials, the decrease in successful performance from Last Day 1 ($\underline{P}$ = .91) to Last Day 30 ($\underline{P}$ = .77), yielded a .14 decrease in success which was not significant. With a = .05, $\underline{n}$ = 22, power = .18, and no statically significant differences were found regarding skill retention.

Estimating skill retention using the report skill acquisition criteria of two or more successful trials, the decline in the proportion of Report Skilled soldiers from Day 1 ($\underline{P}$ = 1.00) to Day 30 ($\underline{P}$ = .77) yielded a difference of .23. This difference was significant, $\underline{n}$ = 22, $\underline{p}$ = .002, power = 1.00. Using the data from all three Day 30 report trials, the skill acquisition performance criteria provided evidence of a significant .23 decrease in report skill over the 30 day retention period.

Considering report skill recovery with practice during Day 30 trials, the success rate for reports did not change from the First Day 30 ($\underline{P}$ = .77) to the Last Day 30 ($\underline{P}$ = .77) trials. With a = .05, $\underline{n}$ = 22, power = .05, and no significant differences were found.

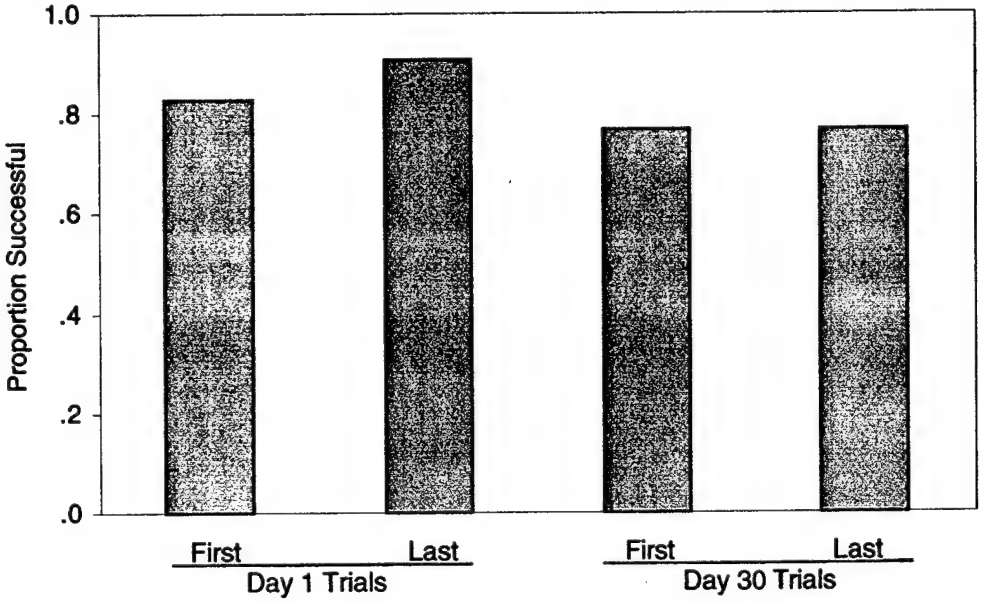


Figure 8. Proportion of Report Skilled soldiers successfully completing reports for comparison trials.

IVIS Overlay skill retention: performance time. The IVIS Overlay task performance times for successful trials were compared to provide estimates of overlay skill learning, retention, and skill recovery. A summary of overlay task performance times for the Overlay Skilled group is provided as Figure 9. Appendix Q provides the summary results of paired t-tests (2-tailed) comparing overlay trial times. It should be noted that the mean trial performance time and sample size differs across trials based on the number of soldiers having valid data for both trials in a specific comparison. Only successful trial performance times are included in calculations, so that comparison sample size ranges from a low of five, to a high of 15 soldiers.

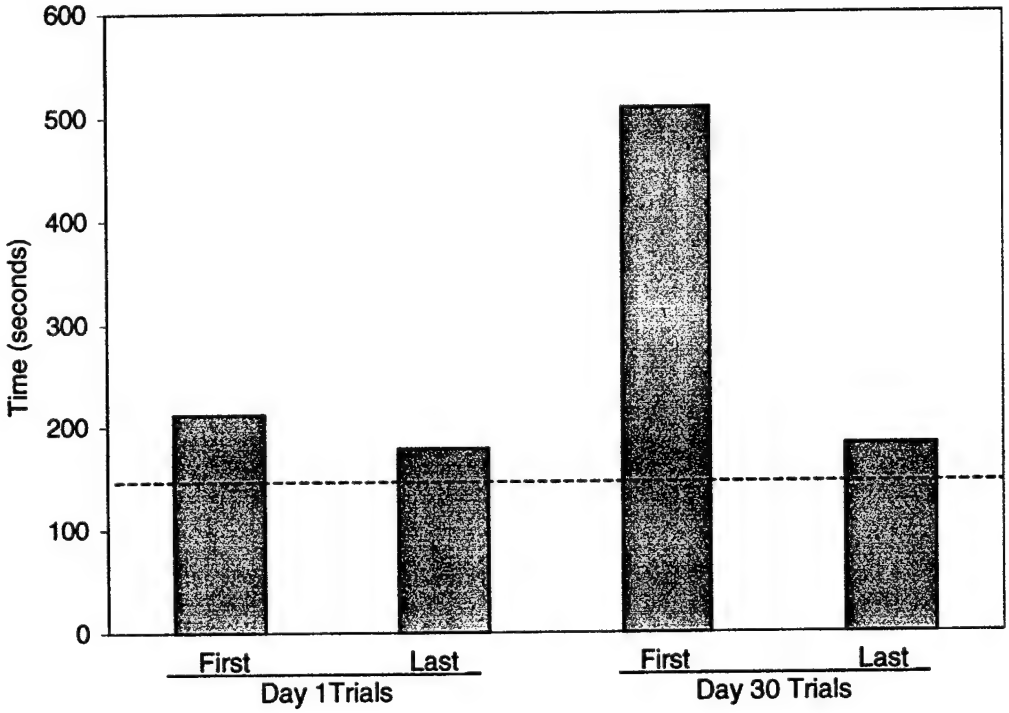


Figure 9. Overlay task performance times for comparison trials. Note. The dashed line represents the 150 second mean time required by the IVIS SME to successfully complete overlay tasks.

Examining first the issue of learning during Day 1 trials, the time (in seconds) required to successfully complete Day 1 trials showed a significant decline from First Day 1 (M = 214, SD = 62) to Last Day 1 trials (M = 179, SD = 36), $t(14) = 2.994$, $p < .01$, power = .80 (paired t-test, 2-tailed). This reduction in task performance time provided evidence that significant overlay skill learning was taking place during the Day 1 trials, beyond what had been achieved in the Day 1 training.

Investigating skill retention immediately following the 30 day retention interval, the comparison of Day 1 and Day 30 overlay task performance times provided evidence of significant skill decay. The 321 second increase in performance time from Last Day 1 (M = 197, SD = 48) to First Day 30 (M = 518, SD = 222) was significant, $t(4) = 3.861$, $p < .05$, power = .82, suggesting that participants were less proficient in performing IVIS overlay tasks immediately after the 30 day retention period.

Considering whether skill decay remains on Day 30 after soldiers had practice with the seven Day 30 trial tasks, the 18 second decrease in performance time from Last Day 1 (M = 178, SD = 51) to Last Day 30 (M = 160, SD = 31) was not significant $t(6) = 1.723$. With $a = .05$, $n = 7$, and an effect size of 18 seconds, power = .31. For a time difference this small power is extremely low, and no statistically significant differences were found between the compared trial times.

Investigating whether skill recovery occurred with practice on Day 30 trials, the 315 second reduction in successful task performance times from the First Day 30 (M = 491, SD = 218) to the Last Day 30 (M = 176, SD = 33) trials was significant, $t(4) = 3.688$, $p < .05$, power = .78, and provided evidence of overlay skill recovery with practice during the Day 30 trials.

Performance time appears to be an essential criteria for estimating IVIS task performance. For the present study the overlay task success rate did not improve across Day 1 trials. However, the significant reduction in task performance time did provide evidence of skill recovery with unaided practice.

IVIS Report skill retention: performance time. A summary of successful report task performance times for the Report Skilled group is provided as Figure 10, while Appendix R provides the summary results of paired t-tests comparing successful report trial times. Examining first the issue of additional skill learning during Day 1 trials, the time required to successfully complete Day 1 trials showed a 47 second decline from First Day 1 (M = 148, SD = 39) to Last Day 1 (M = 101, SD = 18) trials which was significant, $t(16) = 6.208$, $p < .001$, power = 1.00 (paired t-test, 2-tailed). This reduction in task performance time provides some evidence that report skill learning was taking place during the Day 1 trials, beyond what had been achieved in Day 1 training.

Considering skill retention without practice on Day 30, the comparison of Day 1 and Day 30 report task performance times provided evidence of significant skill decay over time. The 52 second increase in performance time from Last Day 1 (M = 102, SD = 25) to First Day 30 (M = 154, SD = 45) was significant, $t(15) = 5.383$, $p < .001$, power = 1.00. This increase in performance time suggests that participants were less proficient in performing IVIS report tasks immediately after the 30 day retention period, and prior to practice with the seven Day 30 trials.

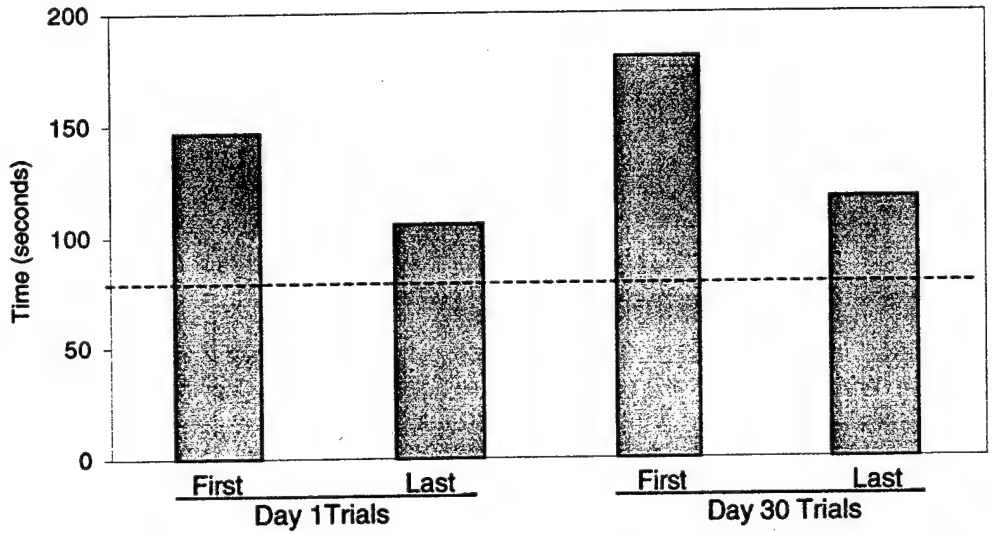


Figure 10. Report task performance times for comparison trials. Note. The dashed line represents the 78 second mean time required by the IVIS SME to successfully complete report tasks.

Examining whether report skill decay remained after practice with Day 30 trials, performance time increased 15 seconds from Last Day 1 (M = 104, SD = 25) to Last Day 30 (M = 119, SD = 44) which was not significant, $t(15) = 1.327$, power = .24.

Investigating whether there was skill recovery with practice during the Day 30 trials, the 72 second performance time decrease from the First Day 30 trials (M = 187, SD = 124) to the Last Day 30 trials (M = 115, SD = 46) was not significant. With $a = .05$, $n = 15$, and an effect size of 71 seconds, power = .52, and no statistically significant differences between the compared trials were found. While the comparison of trials yields a large time difference, the standard deviation of First Day 30 trials is also quite large, which lowers power and impacts the significance test.

Predicting skill retention with the User's Decision Aid. The User's Decision Aid skill retention rating scale developed by Rose, Czarnolewski, Gragg, Austin, Ford, Doyle, and Hagman (1985) was employed in the present experiment to provide a skill retention estimate that represents the expected proportion of soldiers in a unit able to perform a task correctly after a period of one month without training. The author and primary instructor rated the overlay and report tasks presented in the experiment using the ten item task characteristic rating scale. Individual ratings for the ten scale items are provided as Appendix S. The resulting predicted retention estimates were compared to the observed Day 30 overlay and report task success rates. Specific User's Decision Aid retention estimates are based on the assumption that 100% of soldiers were initially trained to proficiency. The IVIS skills acquisition criteria of three or more successful overlay tasks, and two or more successful report tasks was used to establish groups of soldiers with 100% Day 1 skills proficiency, and was also employed as the equivalent Day 30 skill retention criteria.

A binomial probability test for comparing observed values against the predicted retention proportion was used for the evaluation. A two-tailed test was conducted as ratings might over predict, or under predict observed values. Using Cohen's (1988) convention for values associated with a large effect size (.75 vs. .50), with a = .05 (2-tailed), n = 21, power for the comparisons would be .67.

The skill retention rating method predicted that .67 of the Overlay Skilled group would achieve the proficiency criteria again on Day 30. In Day 30 hands-on testing 10 soldiers (48%) successfully met the criteria by completing three or more overlay trials. A binomial probability test comparing the observed against the predicted retention proportion was not significant. The 95% confidence interval for the population proportion shows that the values of the proportion supported by the data lie between .29 and .68. For the given effect size (population proportion = 0.48, tested against a constant of .67), n = 21, and a = .05, (2-tailed), power was .40. Here, 40% of studies would be expected to yield a significant effect, rejecting the null hypothesis that the population proportion was .67.

For the report task 22 soldiers remained in the Day 30 Report Skilled sample. The skill retention rating method predicted that .92 of the Report Skilled group would achieve the Skill Acquired criteria again on Day 30. In Day 30 hands-on

testing 17 soldiers (77%) successfully met the criteria by completing two or more report trials. A binomial probability test comparing the observed against the predicted retention proportion was significant, n = 22, p = .01, power = .40. The 95% confidence interval for the population proportion shows that the values of the proportion supported by the data lie between .56 and .90. Here, 40% of studies would be expected to yield a significant effect, rejecting the null hypothesis that the population proportion is .92.

Issue 3: Digital Skill Subtask Assessment

Measuring performance at the subtask level provides a useful way of summarizing and organizing performance information that can help training developers to focus their limited resources on specific problem areas. In an effort to identify where performance problems occur, and how training might be modified to address these problems, the IVIS overlay and report tasks were divided into subtasks. For this research, subtasks were defined as clusters of separate actions which must be performed as a step-by-step sequence. Four overlay subtasks were identified from a review of the 23 action steps required for task performance, and incorporated into the video data reduction sheets used to capture performance data. The subtasks paralleled the instructional subdivisions in the M1A2 NETT lesson plan.

The four IVIS overlay subtasks identified for this research were:

1. Navigate: Navigate through mode and menu options to arrive at the IVIS graphics menu.
2. Graphic: Use menu options and cursor controller to place a two-point graphic on the map display.
3. TRP: Use menu options and keypad to place a Target Reference Point on the map.
4. Send: Using menu options send the overlay information.

Five report subtasks were also identified from a review of the 19 action steps required for task performance, and incorporated into the video data reduction sheets used to capture performance data. Report subtasks identified for this research were:

1. Navigate: Navigate through mode and menu options to arrive at the IVIS Spot Report menu.

2. Target Grid: Use thumb cursor to place a target icon on the map display.
3. Target Type: Use menu options to select target type, subtype, and number of targets.
4. Activity: Use menu options to enter Friendly Action and Enemy Activity description.
5. Send: Using menu options send the report information.

Overlay subtask performance. Using the video data reduction sheets, task performance errors were assigned codes identifying the subtask to which they belonged. The frequency of overlay subtask errors occurring in the first and last trials on Day 1 and Day 30 for the full sample of 28 soldiers is presented in Figure 11. From this figure it appears that the majority of overlay task performance errors occurred in the TRP and Send subtasks, with an increase in errors, after the 30 day delay. These results might be used to focus limited training resources on the TRP and Send subtask problem areas that show high payoff potential in terms of error reduction.

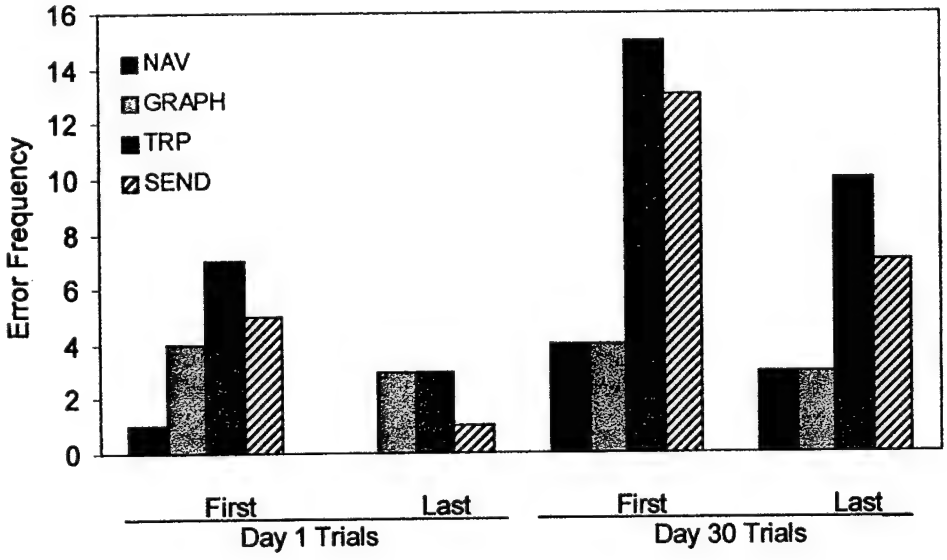


Figure 11. Frequency of overlay subtask errors across trials.

Report subtask performance. The frequency of report subtask errors occurring in the first and last trials on Day 1 and Day 30 for the Report Skilled group is presented in Figure 12. Day 1 errors primarily occurred on the Target Grid, Target Type, and Enemy Action subtasks, with no errors occurring for the Navigation subtask. For Day 30 trials the error pattern changes somewhat, as soldiers made errors with Grid coordinates

while Target Type, Enemy Action, and report Send subtasks showed increased errors. These findings would suggest that report task errors were not very frequent and were distributed across all subtasks except Navigation.

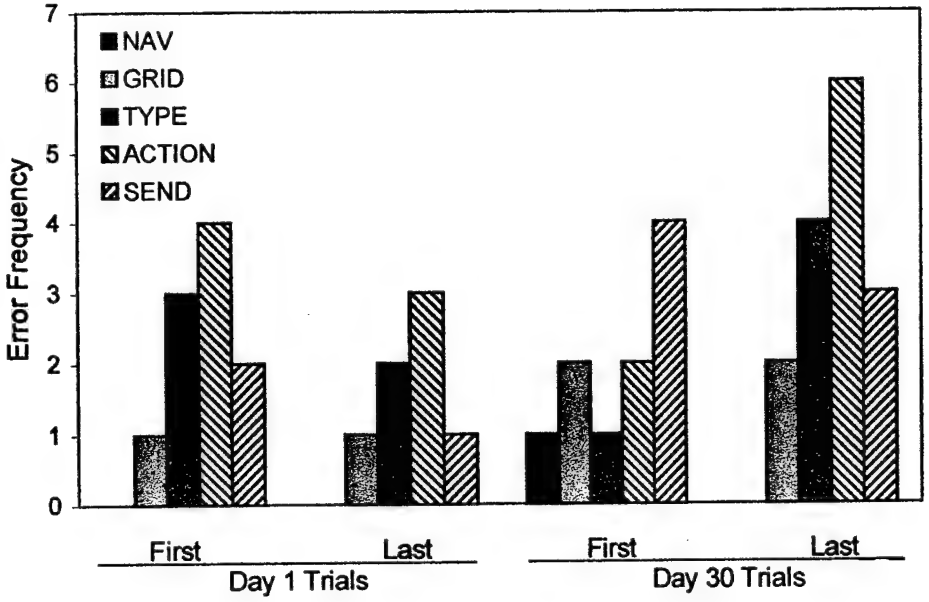


Figure 12. Frequency of report subtask errors across trials.

Subtask time assessment. The problem of obtaining performance time data for unsuccessful trials can be partly resolved by subdividing tasks into successful and unsuccessful subtasks, so that time data can be obtained from successful subtasks occurring within unsuccessful trials. For the present research IVIS overlay subtask performance times were recorded during video data reduction using the video data reduction sheets (Appendix B). Results of the First Day 30 overlay trial for the Overlay Skilled group provides an example of the potential utility of subtask level task time assessment. Only six participants successfully completed this task, providing only six successful task performance times. By separating the overlay task into subtasks, successful subtasks providing additional useful time data were identified. Compared to only six successful First Day 30 overlay task times, there were First Day 30 times available for 19 successful Navigation subtasks, 17 Graphic subtasks, 16 TRP subtasks, and 11 Send subtasks.

Figure 13 presents a comparison of overlay subtask completion time across trials for the full population of 28 soldiers. This figure suggests that while there was a general

increase in time required to perform subtasks immediately following the 30 day retention period, the TRP subtask in particular appears to have contributed to the increased First Trial Day 30 time requirement. Using performance time as the criteria it appears that the TRP subtask represents the area where the greatest payoff might be gained during efforts to focus training to reduce task performance time.

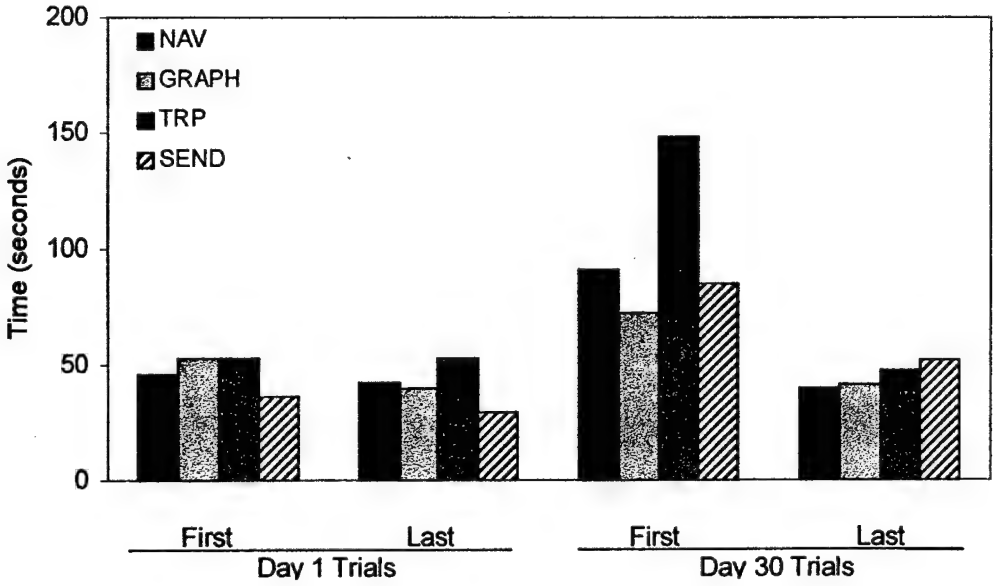


Figure 13. Overlay subtask completion times across trials.

Issue 4. Digital Skill Task Step Assessment

Specific subtask step errors were scored during data analysis as a means of identifying where performance problems occurred, and the nature of the problem. A summary of frequent Day 30 IVIS overlay and report task step errors for each subtask is presented as Appendix T. For each step error a description of the error and possible corrective actions are provided. A complete list of overlay and report task step errors for the full sample of 28 soldiers by frequency and type appears in Appendix U.

Identifying sources of performance errors. Error descriptions in Appendix T might be useful to training developers in suggesting specific task steps to focus training revision efforts on, whether through changes in classroom training or equipment design. As example, for both the Navigate and Send subtasks, participants would enter a software display and fail to recognize that the system required them to select

one IVIS overlay from a list prior to moving on to the next task step. No cue was provided to tell the operator to "Choose an Overlay." With regard to the placement of Graphics, some participants failed to remember the basic procedure for finding a location on a map. With regard to the TRP subtask, errors here reflected a failure to remember material provided in the Day 1 lecture, and the instructions written on the task card, where participants were told that they must use the IVIS keypad to enter precise TRP coordinates.

Some problems appeared to reflect a logical (but false) assessment of the literal meaning of system cues. In the overlay task, soldiers often selected "CONTINUE" when attempting to begin the second graphic, instead of the correct "RETURN" menu option. In the report task soldiers forgot that the "SEND" option doesn't actually send the report. Having identified these specific misunderstandings, additional training emphasis could be selectively focused on reinforcing the correct meaning of these menu options, emphasizing for example, that "the SEND option does not actually send the overlay or report."

While investigating report task performance errors it was noted that there was no procedure in the IVIS lesson plan for clearing target data errors from a Spot Report. This problem was compounded by the software design, which retains target data in the Spot Report even if the soldier tries to clear all entries by quitting without sending the report. Having identified the problem, the necessary procedure to eliminate bad data could be included in a revision of the lesson plan.

Soldiers (predictably) showed tendencies toward caution in performing IVIS tasks. In the absence of obvious "Mail Sent" feedback from the system, soldiers would send duplicate messages over multiple nets. These performance errors have little impact in a training environment, but could overload a digital communications network during combat operations with blank reports, redundant information, and inappropriate message traffic. By scoring and quantifying this behavior, the training manager can identify where soldiers' good intentions lead to bad habits, and the need for warnings against this behavior in the lesson plan. Even a simple list of frequently made errors could provide a trainer with a useful set of warnings to discuss with soldiers receiving training.

Feedback to soldiers during training. The identification of IVIS subtask and step errors suggests information that might be provided as feedback to the soldier during training. The

IVIS equipment presents a prompt window asking the operator to save his work if he attempts to leave the graphics mode without first selecting the Save option. IVIS detects that new graphics have been created but not saved, and prompts the operator to the appropriate action. This same functionality might be applied to other task steps that were found to have high error rates. As example: The most frequently encountered errors for the First Day 30 overlay trials involved participants attempting to create graphics, or send a completed overlay, without first identifying which overlay was to be created or sent. Using the current functionality of the IVIS "SAVE" prompt, the system might provide the prompt "Select Overlay" to remind the soldier that this task step must be completed.

Issue 5. IVIS Psychomotor Skill Assessment

In examining the contribution of psychomotor skill to IVIS task performance it was necessary to investigate whether this skill showed consistency across trials, suggesting that it might represent an individual difference characteristic. The relationship between psychomotor skills and IVIS overlay and report task performance was also investigated to identify whether these skills might make a significant contribution to task performance. Finally, psychomotor skills were investigated to identify whether they showed a pattern of retention over time similar to that displayed for IVIS task performance. If psychomotor skills were related to task performance, and showed decay over the 30 day retention interval, then these skills might represent a high priority training requirement, and justify the expense of the high fidelity CCHA IVIS interface training equipment.

The full sample of 28 soldiers was used in the psychomotor analyses to provide the broadest possible range of performance values, including those for soldiers who failed to meet the IVIS Skill Acquired performance criteria on Day 1. Each of the 28 soldiers performed four psychomotor tasks for a total of 110 trials (one soldier was transferred and failed to complete the two Day 30 trials). Task time was used as the performance criteria for the analyses, but task success was not, as there were only five examples of partial task failure (failure to highlight a number) across the 110 trials.

Psychomotor skill consistency across trials. A correlation matrix was calculated to investigate whether psychomotor skill proficiency was related to overlay and report Day 30 task performance (see Appendix V). From this matrix it was observed

that First Day 1 psychomotor task performance times were significantly related to Last Day 1 times (r = .588, p < .001, First Day 30 times (r = .642, p < .001), and Last Day 30 times (r = .450, p < .001). These findings provide some evidence that psychomotor task performance times showed consistency across trials, and might represent an individual characteristic.

Psychomotor skill relationship to IVIS task success. The correlation matrix presented in Appendix N provides a comparison between the four psychomotor trials and the total number of successful Day 1 and Day 30 overlay and report trials. Results of the 16 comparisons identified only a single significant relationship between Last Day 30 psychomotor trial time and the sum of successful Day 30 overlay trials (r = .377, p < .05). These results provided little evidence that differences in psychomotor skills (as measured by the CCHA cursor placement task) shared a relationship with task performance.

Psychomotor skill retention. A graphic summary of psychomotor performance times is provided as Figure 14. Summary results of paired t-test (2-tailed) comparisons of psychomotor task performance times (in seconds) for the Overlay Skilled group are provided as Appendix W. The Overlay Skilled sample was selected so that psychomotor skill retention results would be directly comparable to the overlay procedural skill retention results. Examining psychomotor skill learning across Day 1 trials, results showed a significant decrease of approximately 23 seconds in performance time from First Day 1 (M = 90, SD = 23) to Last Day 1 trials (M = 67, SD = 7), $t(21)$ = 5.484, p = .001, power = 1.00, suggesting that significant learning was taking place in terms of reduced task performance time.

Looking at psychomotor skill retention immediately following the 30 day retention interval, the comparison of Last Day 1 (M = 66, SD = 7) and First Day 30 trials (M = 69, SD = 8) yielded an increase in performance time of only 3 seconds. With a = .05, n = 21, and an effect size of 3 seconds, power = .25. For this small time difference power is extremely low, and no statistically significant differences between the compared trials were found.

Investigating whether psychomotor task performance times showed a recovery of skill on Day 30 trials, the comparison showed a significant decrease of approximately 5 seconds from First Day 30 (M = 69, SD = 8) to Last Day 30 trials (M = 64,

SD = 8), t(20) = 2.861, p = .01, power = .79 suggesting a significant improvement or recovery of psychomotor skill in the form of reduced task performance time.

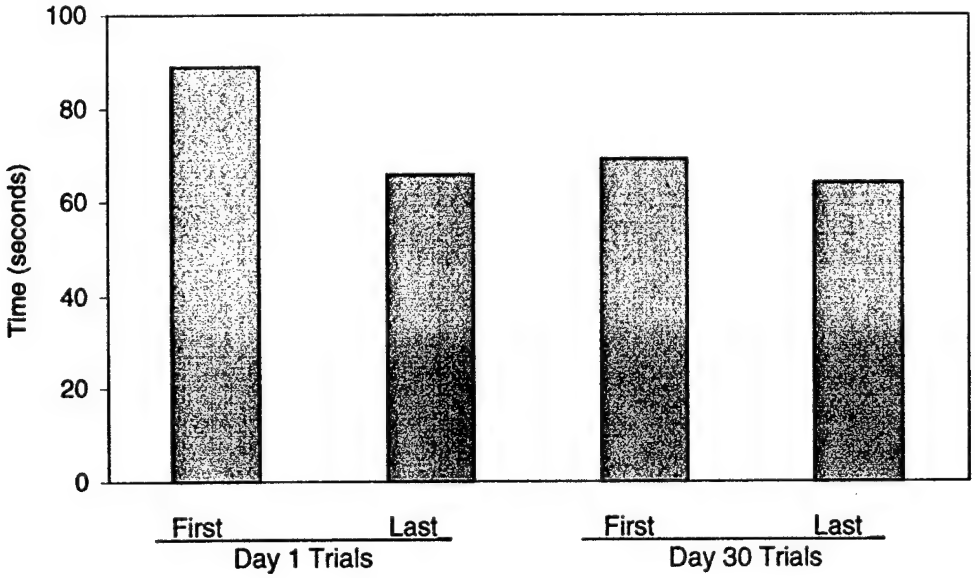


Figure 14. Psychomotor performance times across trials.

Examining psychomotor skills retention after practice on Day 30 tasks, trials for Last Day 1 (M = 66, SD = 7), and Last Day 30 (M = 64, SD = 7) were compared. With a = .05, n = 21, and an effect size of only 2 seconds, power = .19. For this small time difference power is extremely low, and no statistically significant differences between the compared trials were found. Given the lack of power for the comparison, the results do not provide evidence of a lack of psychomotor skill decay after the 30 day retention interval.

In summary, the results provided evidence that individual soldier psychomotor task performance times showed consistency across Day 1 and Day 30 trials. The results did not provide evidence of any relationship between psychomotor task times and IVIS task success. Comparing psychomotor tracking task performance times across the four trials, results provided evidence of significant motor skill learning across Day 1 trials, and significant skill recovery with practice on Day 30 trials. The results showed that the relative levels of psychomotor skill were very similar at the end of Day 1 and Day 30 trials.

Issue 6. Declarative Knowledge Assessment

Declarative knowledge scale reliability. In examining the relationship between declarative knowledge and IVIS task performance, it was necessary to first establish the reliability of the seven-item declarative knowledge scale. Here, reliability bears on the interpretation of any relationship found between declarative knowledge scores and task success. If scale reliability was low, the relation could not be high. Cronbach's alpha for estimating scale reliability based on the internal consistency of the scale items was calculated. The full sample of 28 soldiers was included in the calculation to provide the broadest possible range of scores. Cronbach's alpha for the declarative knowledge scale was a = .70 for the Day 1, a = .47 for Start Day 30, and a = .69 for End Day 30 administrations of the questionnaire, which suggests that the scale has moderate internal reliability. An absolute standard for scale reliability has not been set as the utility of a scale will be a function of both reliability and the practical benefits associated with using the scale.

In addition to Cronbach's alpha, test-retest correlations were computed to estimate the reliability of the declarative knowledge seven-item scale across Day 1 and Day 30 evaluations. The correlation matrix showing the relationship between the three declarative knowledge evaluation scores and the sum of successful overlay and report trials for Day 1 and Day 30 evaluations is provided as Appendix X. Examining declarative knowledge test-retest reliability, there was a significant correlation between Day 1 and First Day 30 evaluations (r = .43, p < .05) and between Day 1 and Last Day 30 evaluations (r = .60, p < .001). These findings suggest that the Day 1 declarative knowledge test seven-item scale did show evidence of significant test-retest reliability across Day 1 and Day 30 trials.

Declarative knowledge scores and IVIS task success. Research suggests that information stored as declarative knowledge is retained better than simple procedural knowledge (Druckman & Bjork, 1991). The scores on the Day 1 declarative knowledge test for the full sample of 28 soldiers were first compared to the total number of successful Day 1 overlay and report trials, and were found to be significantly related to total successful Day 1 overlay trials (r = .57, p < .001, n = 28), and report trials (r = .59, p < .001, n = 28) (1-tailed correlation). A validity coefficient was calculated to estimate the strength of the relationship between the paper and pencil test of IVIS knowledge, and hands-on task performance 30 days

later. Appendix V presents the full correlation matrix of declarative knowledge scores and overlay and report success. A significant relationship was found between Day 1 declarative knowledge scores and the total number of successful Day 30 overlay trials (r = .35, p < .05, n = 27), and successful Day 30 report trials (r = .67, p < .01, n = 29). These results suggest that the seven-item declarative knowledge test shares something in common with factors contributing to Day 30 hands-on task performance.

Declarative knowledge retention. One goal of the present evaluation was to identify whether declarative knowledge scores would show retention trends similar to procedural tasks. Declarative knowledge test mean scores are presented graphically in Figure 15. The summary results of paired t-test comparisons of declarative knowledge test scores are provided as Appendix Y. The Overlay Skilled sample was selected so that declarative knowledge results and overlay task retention results would be based on the same group of soldiers.

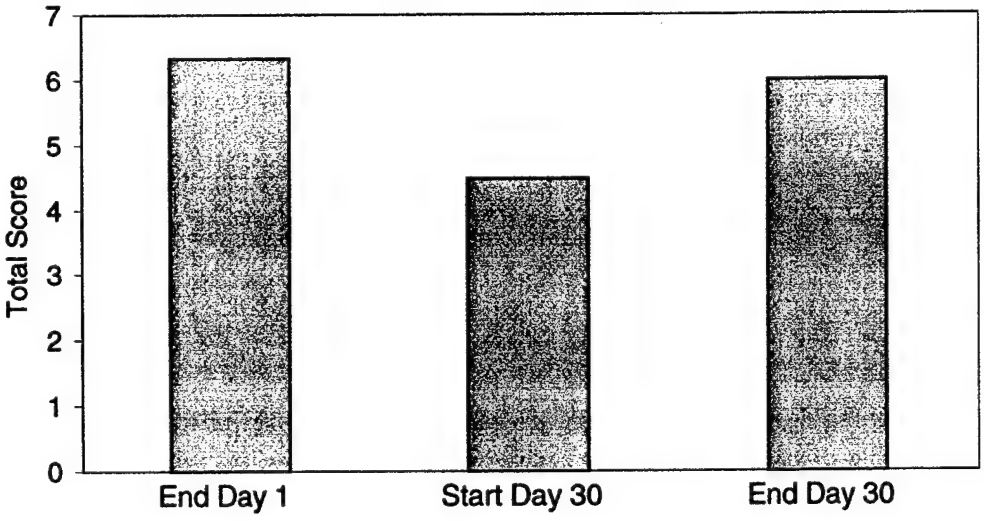


Figure 15. Declarative knowledge scores comparison.

As indicated in Appendix X, the decrease in test scores from Day 1 (M = 6.33, SD = 1.06) to First Day 30 (M = 4.48, SD = 1.25) evaluations was statistically significant, $t(20)$ = 6.669, p < .001, power = 1.00, and suggested that participants did forget some IVIS overlay and reports task procedures as measured by the seven-item questionnaire over the 30 day delay.

Examining declarative knowledge skill decay after soldiers had practice on the Day 30 tasks, the decrease in test scores from Day 1 (M = 6.33, SD = 1.06) to Last Day 30 (M = 6.00, SD = 0.89) was not significant, $t(20) = 1.435$. With $a = .05$, $n = 21$, and an effect size of .33, power = .24. For this small difference in test scores power is extremely low, and no statistically significant differences between the compared trials were found.

Examining skill recovery, test scores improved significantly after practice on the seven Day 30 tasks. The difference between First Day 30 (M = 4.48, SD = 1.25) and Last Day 30 scores (M = 6.00, SD = 0.89) was statistically significant, $t(20) = 4.544$, $p < .001$, power = .99, and provided evidence that soldiers recovered IVIS task cognitive skill with practice during the Day 30 trials.

In summary, the seven-item declarative knowledge multiple choice test did show moderate internal reliability. A significant relationship was found between Day 1 declarative knowledge scores and Day 30 task success for both IVIS overlays and reports. The results provided evidence of a significant decay in task knowledge over the thirty day retention interval, and a significant recovery of this knowledge with practice during Day 30 trials. The results do not support any conclusions regarding the relative levels of task knowledge at the end of Day 1 and Day 30 to indicate whether any skill loss remained after practice with Day 30 trials.

Demographic Factors Evaluation

The relationship between eight demographic measures and Day 30 overlay and report task success was explored using Pearson correlation coefficients. Detailed results of the evaluation are presented as Appendix Z. For this evaluation, demographic measures were compared to the total number of successful Day 30 overlay trials, and report trials. The full population of 28 soldiers was included to provide the broadest possible range of scores. Of the eight demographic factors evaluated, only two items addressing computer usage showed a significant relationship with IVIS task performance. Responses to the question "Approximately how often do you use a computer each month?" ranged from "Never" to "Daily" and showed a significant relationship with the total number of successful Day 30 Overlay trials ($r = .41$, $p < .05$, $n = 27$). Responses to the question which asked soldiers to report their experience with computers

in terms of years showed a significant relationship with the total number of successful Day 30 Report trials (r = .41, p < .05, n = 27).

Questions addressing soldier motivation to learn tasks on Day 1 and to perform tasks on Day 30 were included in the IVIS System Procedures Review questionnaires to assess whether soldier motivation might be a factor contributing to task performance. On the Day 1 questionnaire all 28 participants indicated that they were either "Very Motivated," or "Fairly Motivated" to learn IVIS tasks, with no soldiers selecting the "Fairly Unmotivated," or "Very Unmotivated" response options. On the Day 30 questionnaire all 27 of the remaining soldiers indicated that they were either "Very Motivated," or "Fairly Motivated" to perform IVIS tasks that day. These results provide some evidence that skill acquisition on Day 1, and skill retention Day 30, were not depressed by a lack of soldier motivation.

Discussion

Skill Retention Overview

The present research met the goal of developing empirical estimates of procedural skill retention for selected M1A2 IVIS digital communications tasks. Results showed a significant 52 percent decrease in the proportion of soldiers able to meet the Overlay Skilled criteria after the 30 day retention interval for IVIS overlay tasks. Results also revealed a 23 percent decrease in the proportion of soldiers meeting the Report Skilled criteria. Psychomotor skill did not show significant decay after the 30 day retention interval, and also failed to show a relationship with overlay or report task success. Declarative knowledge of task procedures showed significant decay after 30 days, however this knowledge was recovered with hands-on experience during the Day 30 evaluation trials. The present research provided evidence of a significant relationship between the seven-item declarative knowledge test scores and Day 30 overlay and report task hands-on performance.

The research design stressed that an assessment of initial skill acquisition was a necessary prerequisite to any investigation of skill retention. In examining skill retention, multiple comparisons were employed to estimate Day 1 proficiency, Day 30 skill retention, and the ability of soldiers to recover skills with practice on Day 30 trials. An error coding method was developed which could aid training developers in

resolving training and equipment design issues. The error coding method identifies the source of performance problems at the task, subtask, and individual task step level. While focusing primarily on procedural aspects of task performance, the research also investigated the retention of declarative knowledge, and psychomotor skill, and their relationship with task success.

Digital Procedural Skill Acquisition

Skill acquisition is a prerequisite condition for any assessment of skill retention. In the present experiment 21 percent of the soldiers in the full sample failed to meet the Overlay Skilled criteria, and 18 percent failed to meet the Report Skilled criteria during Day 1 training and evaluation. The scores for these soldiers were not included in the procedural skill retention estimates. Failure to eliminate the non-skilled soldiers scores would have resulted in an underestimate of skill retention, reducing the proportion of soldiers meeting the Day 30 Overlay Skilled criteria from 48 percent to 41 percent. Likewise, the inclusion of soldiers who failed to attain the Report Skilled criteria on Day 1 would have reduced the apparent Day 30 Report Skilled retention rate from 77 percent to 67 percent. These findings suggest that anecdotal accounts of digital skill decay from field trials might provide an underestimate skill retention by failing to differentiate between those soldiers who have lost skills, and those who did not initially acquire the skills.

Digital Procedural Skill Retention

Measuring IVIS skill retention at the task, subtask, and individual task step levels yielded information that could greatly assist training developers in their efforts to identify and prioritize training revision and equipment design requirements. The IVIS task performance errors were treated as misunderstandings, rather than random mistakes, and systematically coded and quantified so that the source of the misunderstanding could be identified.

Task level assessment of retention. Results of the present research revealed a significant 52 percent drop in overlay task proficiency 30 days after training, and a significant 23 percent drop in report task proficiency. This task level assessment provides a useful summary of the magnitude of observed skill loss, however it does not identify the source of performance

problems and thus fails to provide a direction for training redesign efforts.

Subtask level assessment of retention. Subtasks were defined as clusters of separate actions which must be performed as a step-by-step sequence. The identification of subtasks for IVIS overlay and report tasks advances the measure of skill retention beyond a simple task success rate. In the present research, subtask retention assessment identified IVIS overlay TRP and SEND subtasks as contributing most to the observed Day 30 reduction in task success. Likewise, the failure to retain IVIS report ACTION and SEND subtask skills was identified as the primary source of Day 30 report skill loss. These subtask level skill retention results might suggest to training developers the need to investigate why soldiers failed to complete the steps necessary to send a message for both overlay and report tasks.

Task Step Level Assessment of Retention. The collection and analysis of task step performance data was extremely useful in identifying the source of performance errors. Task step coding provided the quantitative data necessary to identify specific recurring errors where soldiers repeatedly selected an incorrect (but often logical) response alternative. The task step analysis also helped to identify the location in the IVIS lesson plan where emphasis might be placed to correct misunderstandings, or where essential information could be added. The present research identified a recurring error where soldiers would select the "SEND" option and exit the task, not realizing that the "SEND" option does not complete the action of sending an overlay or report. The detailed step level analysis also revealed that training materials failed to provide a procedure for correcting target data entry mistakes in the Spot Report. These results illustrate the value of recording task step performance data to facilitate training and training system development.

Psychomotor Skill Assessment

The present research investigated the retention of IVIS related psychomotor skill, and its relationship with digital procedural task performance. Results of the research suggested that psychomotor skills associated with the IVIS CCHA interface did not show significant decay after the 30 day retention interval. Likewise, results provided little evidence that psychomotor skill shared a relationship with overlay and report task performance.

One goal in exploring psychomotor skill was to demonstrate how this type of information could assist training developers in prioritizing training system requirements. The CCHA hand controller provided with the CST is an expensive full-fidelity training tool. With IVIS software now being hosted on desktop personal computers, the cost of the CCHA can equal the cost of the remaining components in the CST training system. Given the minimal learning and absence of decay associated with IVIS psychomotor skill, the present research raised the issue of whether the expense of a full fidelity CCHA hand controller was justified.

Declarative Knowledge Skill Assessment

The present research investigated the retention of declarative knowledge of IVIS task procedures, and suggested training requirements associated with acquiring and maintaining this skill. Declarative knowledge of task procedures showed significant decay after 30 days, however this knowledge was recovered with unaided hands-on experience during the Day 30 evaluation trials. Results revealed a significant relationship between the seven-item declarative knowledge Day 1 test scores and Day 30 overlay and report task hands-on performance.

The significant relationship found between IVIS task procedure declarative knowledge and hands-on performance has important implications for the way training developers design and deliver course instruction. The NETT approach to IVIS training could be characterized as training to a level of procedural knowledge, where soldiers followed the instructors verbal instructions to perform overlay and report sequential task steps on CSTs. Written training materials were not provided, and little emphasis was placed on providing a "big picture" summary of the IVIS menu structure and menu organization principles. Training to this procedural level of knowledge could leave the soldier capable of performing overlay and report tasks, but unable to describe, or remember, what task steps were performed, or why.

Training to a declarative level of knowledge has the potential to enhance digital procedural skill retention and should be considered in training development efforts. For IVIS this training approach could be characterized as including instruction and evaluation on the organizing concepts that underlie the digital system menu structure. Here, training could be designed to present soldiers with evaluation tasks that require them to consolidate their hands-on knowledge of task

procedures into clear statements describing how tasks are performed.

Task Characteristics Supporting Skill Retention

In searching for a valid approach to investigate skill retention differences across tasks, the User's Decision Aid skill retention rating scale developed by Rose et al., (1985) was found to provide a useful framework for comparing tasks on a common set of ten retention related factors.

Predicting skill retention. The User's Decision Aid was first employed in the present experiment to provide skill retention estimates for overlay and report tasks. The comparison of observed (48%) to predicted (67%) overlay skill retention was not significant, while the comparison of observed (77%) to predicted (92%) report skill retention was significant. The results of this comparison were mixed, with the report task comparison showing a significant difference between observed and predicted skill retention. For both overlays and reports the rating method tended to under-predict retention loss.

Overlay and report retention factor comparison. Results of the present research do not directly address the question of why overlay tasks appear to show greater skill loss (52%) than do report tasks (23%) after the 30 day retention interval. It should be noted that a statistical comparison of retention rates is not appropriate as the overlay and report tasks differ with regard to skill acquisition and retention criteria, numbers of tasks presented, and order of presentation. Likewise, a comparison of error trends across tasks has little utility as the subtasks and task steps for overlays and reports are very different.

The User's Decision Aid ten rating factors provide a valuable framework for comparing overlay and report task requirements associated with skill retention. Appendix S presents the ten retention factor ratings for the overlay and report tasks. The ratings indicate that the overlay and report tasks differ in terms of (1) job or memory aid quality, (2) number of facts to remember, (3) how hard facts and terms are to remember, and (4) motor control demands of the task. Comparing overlay and report tasks on the rating factors, the greater skill decay observed for overlay tasks might be a function of the greater flexibility required to create a variety of map graphics, which limits opportunities for job aiding in the form of common language or single function menu labels. In contrast,

the highly structured format of reports allows for menu label job aids that guide the soldier through a fill-in-the-blank task step sequence. The greater flexibility in overlay task requirements may also require the soldier to commit more menu rules to memory rather than providing this information as menu label cues. With regard to motor control demands, the overlay experiment tasks presented a greater number of precision motor skill requirements compared to the report task. For overlay tasks soldiers were required to place two points on each overlay map with +/- 10 meter precision, compared to only one target location with +/- 10 meter precision for report tasks.

Future Directions

Rapid change is an inherent characteristic of software-driven digital communication systems such as the IVIS. Future training research should explore opportunities to shift away from the short-term goal of training single-system procedural tasks, to a long-term training method that prepares soldiers with a knowledge of digital system operating concepts. This concept level knowledge of system operation could facilitate the long-term retention and transfer of skills across changing software and equipment. Here, the increased front-end training costs might be recovered by reducing the requirement for multiple single-system training programs across the duration of a soldiers career.

References

Boldovici, J.A., and Kolasinski, E.M. (1997). How to make decisions about the effectiveness of device-based training: elaborations on what everybody knows. Military Psychology, 9(2), 121-135.

Cohen, J. (1988). Statistical power analysis for the behavioral sciences. (2nd Edition). Hillsdale, New Jersey: Lawrence Erlbaum Associates.

Druckman, D. & Bjork, R.A. (Eds.). (1991). In the mind's eye: Enhancing human performance. Washington, DC: National Academy Press.

Du Bois, R. S. and Smith, P.G. (1991). Simulation-based assessment of automated command, control and communication capabilities for armor crews and platoons: The inter-vehicular information system (Technical Report 918). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Elliott, G., Sanders, W., and Quinkert, K. (1996). Training in a digitized battalion task force: lessons learned and implications for future training (ARI Research Report 1695). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Ford, L., Campbell, R., & Cobb, R. (1998). Analysis of emerging digital and back-up training requirements (Study Report 98-07) Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

General Dynamics Land Systems Division. (1997). M1A2 Crew Station Trainer (CST) User's Manual. Warren, MI., p.2.

Marascuilo, L.A., and McSweeney, M. (1977). Nonparametric and distribution-free methods for the social sciences. Monterey, CA: Brooks/Cole Publishing Company.

McNemar, Q. (1975). Psychological statistics (5th ed.). New York: Wiley. Cited in Hays, W.L. (1988) Statistics (4th ed.). Orlando, FL: Holt, Rinehart and Winston, Inc.

Mengelkoch, R.F., Adams, J. A. & Gainer, C.A. (1971). The forgetting of instrument flying skills. Human Factors, 13, 397-405.

Quinkert, K.A., and Black, B.A. (1994, November-December). Training For Force XXI Technologies. Army Research, Development and Acquisition Bulletin. PB70-94-6

Rose, A.M., Czarnolewski, M.Y., Gragg, F.E., Austin, S.H., Ford, P, Doyle, J., & Hagman, J.D. (1985). Acquisition and retention of soldiering skills (Technical Report 671). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Ryan, T., and Iddins, J.B. (1999, January-February). AGTS Deploys with "First Team" to Bosnia!. Armor, Vol. CVIII No. 1, 62.

Salter, M.S., & Black, B.A. (1998). Back-up training requirements for the digitized battlefield: an overview (Study Report 98-05). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Schendel, J.D., & Hagman, J.D. (1991). Long-term retention of motor skills. In J.E. Morrison, (Ed.), Training for Performance (pp. 53-92). New York: John Wiley & Sons.

Shields, J.L., Goldberg, S.L. & Dressel, J.D. (1979). Retention of basic soldiering skills (Research Report 1225). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

SPSS Inc. (1997). SamplePower (Release 1.00) [computer software]. Chicago, IL: SPSS Inc.

Throne, M. H. & Lickteig, C. W. (1997). Training Computer-Skills for the Future Battlefield: A Review and Annotated Bibliography (Research Product 97-15). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

U.S. Army Armor Center and School (1994). Advanced warfighting experiment: Operation desert hammer VI. Fort Knox, KY: Author. (Available from the Commander, U.S. Army Armor Center and Fort Knox, ATTN: ATZK-PTF-D, Fort Knox, KY 40121-5200.)

U.S. Army Armor Center (1996). Advanced warfighting experiment focused dispatch final report, Mounted Battlespace Battle Lab. (Available from the Commander, U.S. Army Armor Center and Fort Knox, ATTN: ATZK-PTF-D, Fort Knox, KY 40121-5200).

U.S. Army Armor Center and School. (1996a). M1A2 New Equipment Training Team Lesson Plan: Prepare, send, and respond to reports. Fort Knox, KY: Author.

U.S. Army Armor Center and School. (1996b). Tank Platoon SOP. FKSM 17-15-3. Fort Knox, KY: Author.

U.S. Army Armor Center and School. (1997). M1A2 New Equipment Training Team Lesson Plan: Mission Planning. Fort Knox, KY: Author.

U.S. Department of the Army. (1995). Operator's manual, operator controls, PMCS, and operation under usual conditions, tank, combat, full-tracked: 120-MM gun, M1A2 (TM 9-2350-288-10-1). U.S. Army Tank-Automotive and Armaments Command, Warren, MI.

U.S. Operational Test and Evaluation Command. (1997). Test and evaluation report (TER) for the follow-on test of the M1A2 Abrams tank system. Alexandria, VA: Author. (Available from HQ, OPTEC, ATTN: CSTE-ECC, Park Center IV, Alexandria, VA 22301-1458.)

Appendix A

List of Acronyms

AFRU	Armored Forces Research Unit
ARI	Army Research Institute for the Behavioral and Social Sciences
AWE	Advanced Warfighting Experiment
CCHA	Commander's Control Handle Assembly
CST	Crew Station Trainer
CVC2	Combat Vehicle Command and Control
FASTTRAIN	Force XXI Training Methods and Strategies
IVIS	Inter-Vehicular Information System
MEDEVAC	Medical Evacuation
MGRS	Military Grid Reference System
MOS	Military Occupational Specialty
NETT	New Equipment Training Team
OPTEC	Operational Test and Evaluation Command
SINCGARS	Single Channel Ground/Airborne Radio System
SOP	Standard Operating Procedure
SME	Subject Matter Expert
TRP	Target Reference Point

Appendix B

Video Data Reduction Sheets

MISSION PLANNING VIDEO REDUCTION

TASK NUMBER ___1___ TASK SEQUENCE _____ PIN _____

1. Start Time (Press Pre/Post or Combat) _____
2. Stop Time (Press CONFIRM RT A) _____
3. Total Time _____
4. 100% accurate info sent?

Task steps:

YES	NO	ERRORS		
___	___	___	1.	Press PRE/POST or COMBAT (Start NAV: _____)
___	___	___	2.	Press MISSION PLANNING
___	___	___	3.	Press EDIT OVERLAY
___	___	___	4.	**OBSTACLE** overlay
___	___	___	5.	Press GRAPHICS
___	___	___	6.	Press PAGE DOWN/PAGE UP
___	___	___	7.	**MINEFIELD** graphic (Start GRAPH: ___)
___	___	___	8.	**CURSOR** used
___	___	___	9.	Coordinates **2400 2550 and 2400 2500**
___	___	___	10.	Press RETURN
___	___	___	11.	**TRP** selected (Start TRP: _____)
___	___	___	12.	**KEYPAD** used to enter 2300 2750
___	___	___	13.	Coordinate **2300 2750**
___	___	___	14.	Press RETURN
___	___	___	15.	Press LABEL
___	___	___	16.	Enter text **AA0001**
___	___	___	17.	Text entered on **2ND line**
___	___	___	18.	Press RETURN button (Start SEND: ____)
___	___	___	19.	Press SAVE CHANGES
___	___	___	20.	Press SEND OVERLAY
___	___	___	21.	Select OBSTACLE overlay
___	___	___	22.	Select STANDARD ROUTING
___	___	___	23.	Press **CONFIRM RT A**
			24.	Comments code number

COMMENTS:

REPORTS VIDEO REDUCTION

TASK NUMBER 2 TASK SEQUENCE ___ PIN _____

1. Start Time (Press Pre/Post or Combat) _____
2. Stop Time (Press CONFIRM RT A) _____
3. Total Time _____
4. 100% accurate information sent?

Task steps:

YES	NO	ERRORS		
___	___	___	1.	Press COMBAT (Start NAV: _____)
___	___	___	2.	Press REPORTS
___	___	___	3.	Press IVIS REPORTS
___	___	___	4.	**SPOT REPORT** Selected (Start GRID: _____)
___	___	___	5.	**2650 2500** Target coord
___	___	___	6.	CURSOR used to enter target grid
___	___	___	7.	**APC** Selected (Start TGTS: _____)
___	___	___	8.	**BMP** Selected
___	___	___	9.	**(2)**Enter size
___	___	___	10.	**TANK** Selected
___	___	___	11.	**T72** Selected
___	___	___	12.	**(4)** Enter size
___	___	___	13.	**ACTIVITY** Selected (Start ACTIVITY: _____)
___	___	___	14.	**WITHDRAW** Selected
___	___	___	15.	**FRIENDLY ACTION** Selected
___	___	___	16.	**CONTINUE** Selected
___	___	___	17.	Press SEND (Start SEND: _____)
___	___	___	18.	STANDARD ROUTING
___	___	___	19.	Press CONFIRM RT A
			20.	Comments code number

Comments:

PT 60-15

IVIS SYSTEM PROCEDURES REVIEW 1

PIN: _____

Please answer each question below by circling a letter.

1. What mode button would you select first to edit an IVIS OVERLAY?

2	a.	IVIS Reports
26	*b.	Pre/Post or Combat
0	c.	Diag
0	d.	IVIS
0	e.	Map Tools

2. What mode would you choose first to begin sending an IVIS REPORT?

1	a.	Pre/Post
21	*b.	Combat
1	c.	Diag
5	d.	Mission Planning
0	e.	Map Tools

3. Which pushbutton would you select to center the IVIS map around your vehicle?

11	a.	Scroll Off/On
16	*b.	Scroll Home
1	c.	Zoom
0	d.	Location Off/On
0	e.	Vehicle Iden Off/On

4. Which pushbutton would you select to add graphics to an existing overlay?

0	a.	Map Tools
27	b.	Graphics
0	c.	Delete
0	d.	Decltr
1	e.	Label

5. Which pushbutton would you select to temporarily hide selected graphics?

2	a.	Map Tools
2	b.	Graphics
0	c.	Delete
2	*d.	Decltr
0	e.	Label

6. How many characters of text can be entered in one line using the FREE TEXT feature?

0	a.	Four
0	b.	Six
1	c.	Eight
27	*d.	Ten
0	e.	Fifteen

7. When using the alpha numeric keypad, if the data entry point appears as a highlighted box (not a highlighted underline) what will the keypad record?

2	a.	A number
26	*b.	A letter

8. When using the alpha numeric keypad, does the cursor automatically advance one space when you enter a number?

22	*a.	Yes
6	b.	No

9. Circle the letter of the correct sequence you would follow to create a Contact Report.

27	*a.	COMBAT - REPORTS - IVIS REPORTS - CONTACT REPORT
1	b.	PRE/POST - MISSION PLANNING - REPORTS - CONTACT REPORT
0	c.	COMBAT - COMMO - IVIS - CONTACT REPORT
0	d.	PRE/POST - MISSION PLANNING - COMMO - CONTACT REPORT

10. Circle the letter of the correct sequence you would follow to add a graphic to the Enemy overlay.

3	a.	COMBAT - IVIS - EDIT OVERLAY - ENEMY
20	*b.	PRE/POST - MISSION PLANNING - EDIT OVERLAY - ENEMY
5	c.	COMBAT - MISSION PLANNING - DISPLAY OVERLAY - ENEMY
0	d.	PRE/POST - IVIS - DISPLAY OVERLAY - ENEMY

11. How likely is it that you will be able to quickly and accurately create and send an IVIS map OVERLAY one month from today without additional practice?

9 a. Very likely
19 b. Fairly likely
0 c. Fairly unlikely
0 d. Very unlikely

12. How likely is it that you will be able to quickly and accurately create and send an IVIS REPORT one month from today without additional practice?

11 a. Very likely
16 b. Fairly likely
1 c. Fairly unlikely
0 d. Very unlikely

13. How likely is it that you will have to perform computer-based tasks in your current or next assignment?

5 a. Very likely
18 b. Fairly likely
5 c. Fairly unlikely
0 d. Very unlikely

14. How adequately did the CST training prepare you to perform OVERLAY tasks?

25 a. Very adequate
3 b. Fairly adequate
0 c. Fairly inadequate
0 d. Very inadequate

15. How adequately did the CST training prepare you to perform REPORT tasks?

26 a. Very adequate
2 b. Fairly adequate
0 c. Fairly inadequate
0 d. Very inadequate

* Correct response option for items 1 - 10.

PT 60-15

IVIS SYSTEM PROCEDURES REVIEW 2

PIN: _____

Please answer each of the following questions by circling a letter.

1. What mode button would you select first to edit an IVIS OVERLAY?

3	a.	IVIS Reports
16	*b.	Pre/Post or Combat
4	c.	Diag
2	d.	IVIS
2	e.	Map Tools

2. What mode would you choose first to begin sending an IVIS REPORT?

2	a.	Pre/Post
17	*b.	Combat
4	c.	Diag
4	d.	Mission Planning
0	e.	Map Tools

3. Which pushbutton would you select to center the IVIS map around your vehicle?

6	a.	Scroll Off/On
16	*b.	Scroll Home
0	c.	Zoom
4	d.	Location Off/On
1	e.	Vehicle Iden Off/On

4. Which pushbutton would you select to add graphics to an existing overlay?

4	a.	Map Tools
20	*b.	Graphics
0	c.	Delete
0	d.	Decltr
3	e.	Label

5. Which pushbutton would you select to temporarily hide selected graphics?

1	a.	Map Tools
1	b.	Graphics
2	c.	Delete
23	*d.	Decltr
0	e.	Label

6. How many characters of text can be entered in one line using the FREE TEXT feature?

3	a.	Four
2	b.	Six
7	c.	Eight
13	*d.	Ten
2	e.	Fifteen

7. When using the alpha numeric keypad, if the data entry point appears as a highlighted box (not a highlighted underline) what will the keypad record?

9	a.	A number
18	*b.	A letter

8. When using the keypad, does the cursor automatically advance one space when you enter a number?

18	*a.	Yes
9	b.	No

9. Circle the letter of the correct sequence you would follow to create a Contact Report.

22	*a.	COMBAT - REPORTS - IVIS REPORTS - CONTACT REPORT
3	b.	PRE/POST - MISSION PLANNING - REPORTS - CONTACT REPORT
1	c.	COMBAT - COMMO - IVIS - CONTACT REPORT
0	d.	PRE/POST - MISSION PLANNING - COMMO - CONTACT REPORT

10. Circle the letter of the correct sequence you would follow to add a graphic to the Enemy overlay.

9	a.	COMBAT - IVIS - EDIT OVERLAY - ENEMY
7	*b.	PRE/POST - MISSION PLANNING - EDIT OVERLAY - ENEMY
10	c.	COMBAT - MISSION PLANNING - DISPLAY OVERLAY - ENEMY
1	d.	PRE/POST - IVIS - DISPLAY OVERLAY - ENEMY

11. How motivated are you to perform the IVIS tasks in the evaluation sessions today?

18	a.	Very motivated
9	b.	Fairly motivated
0	c.	Fairly unmotivated
0	d.	Very unmotivate

12. How likely is it that you will be able to quickly and accurately create and send an IVIS map OVERLAY today?

5 a. Very likely
19 b. Fairly likely
2 c. Fairly unlikely
1 d. Very unlikely

13. How likely is it that you will be able to quickly and accurately create and send an IVIS REPORT today?

5 a. Very likely
18 b. Fairly likely
2 c. Fairly unlikely
1 d. Very unlikely

14. How likely is it that you will have to perform computer-based tasks in your current or next assignment?

8 a. Very likely
14 b. Fairly likely
4 c. Fairly unlikely
0 d. Very unlikely

15. How adequately did the CST training prepare you to perform OVERLAY tasks?

18 a. Very adequate
7 b. Fairly adequate
1 c. Fairly inadequate
0 d. Very inadequate

16. How adequately did the CST training prepare you to perform REPORT tasks?

18 a. Very adequate
7 b. Fairly adequate
1 c. Fairly inadequate
0 d. Very inadequate

17. Since you completed IVIS OVERLAYS training on the Crew Station Trainer 30 days ago, have you practiced creating an IVIS overlay?

26 No _____
0 Yes _____ (describe below)
Number of times practiced _____
Number of total hours practiced _____
Number of days since last practiced _____

18. Since you completed IVIS REPORTS training on the Crew Station Trainer 30 days ago, have you practiced creating an IVIS report?

26 No _____
0 Yes _____ (describe below)
Number of times practiced _____
Number of total hours practiced _____
Number of days since last practiced _____

* Correct response option for items 1 - 10.

PT 60-15

IVIS SYSTEM PROCEDURES REVIEW 3

PIN: _____

Please answer each of the following questions by circling a letter.

1. What mode button would you select first to edit an IVIS OVERLAY?

1	a.	IVIS Reports
23	*b.	Pre/Post or Combat
1	c.	Diag
0	d.	IVIS
2	e.	Map Tools

2. What mode would you choose first to begin sending an IVIS REPORT?

0	a.	Pre/Post
22	*b.	Combat
0	c.	Diag
5	d.	Mission Planning
0	e.	Map Tools

3. Which pushbutton would you select to center the IVIS map around your vehicle?

8	a.	Scroll Off/On
16	*b.	Scroll Home
0	c.	Zoom
1	d.	Location Off/On
2	e.	Vehicle Iden Off/On

4. Which pushbutton would you select to add graphics to an existing overlay?

1	a.	Map Tools
24	*b.	Graphics
1	c.	Delete
0	d.	Decltr
1	e.	Label

5. Which pushbutton would you select to temporarily hide selected graphics?

__1__ a. Map Tools
__0__ b. Graphics
__1__ c. Delete
__25__ *d. Decltr
__0__ e. Label

6. How many characters of text can be entered in one line using the FREE TEXT feature?

__3__ a. Four
__1__ b. Six
__9__ c. Eight
__12__ *d. Ten
__2__ e. Fifteen

7. When using the alpha numeric keypad, if the data entry point appears as a highlighted box (not a highlighted underline) what will the keypad record?

__2__ a. A number
__25__ *b. A letter

8. When using the keypad, does the cursor automatically advance one space when you enter a number?

__24__ *a. Yes
__3__ b. No

9. Circle the letter of the correct sequence you would follow to create a Contact Report.

__26__ *a. COMBAT - REPORTS - IVIS REPORTS - CONTACT REPORT
__1__ b. PRE/POST - MISSION PLANNING - REPORTS - CONTACT REPORT
__0__ c. COMBAT - COMMO - IVIS - CONTACT REPORT
__0__ d. PRE/POST - MISSION PLANNING - COMMO - CONTACT REPORT

10. Circle the letter of the correct sequence you would follow to add a graphic to the Enemy overlay.

__4__ a. COMBAT - IVIS - EDIT OVERLAY - ENEMY
__16__ *b. PRE/POST - MISSION PLANNING - EDIT OVERLAY - ENEMY
__7__ c. COMBAT - MISSION PLANNING - DISPLAY OVERLAY - ENEMY
__0__ d. PRE/POST - IVIS - DISPLAY OVERLAY - ENEMY

11. How adequately did the CST training prepare you to perform OVERLAY tasks?

__19__ a. Very adequate
__8__ b. Fairly adequate
__0__ c. Fairly inadequate
__0__ d. Very inadequate

12. How adequately did the CST training prepare you to perform REPORT tasks?

19 a. Very adequate
8 b. Fairly adequate
0 c. Fairly inadequate
0 d. Very inadequate

* Correct response option for items 1 - 10.

Appendix D

Overlay Task Elements

Task Number	Overlay	Multiple Point Graphic	Graphic Label
1	Obstacle	Minefield	AA0001
3	Obstacle	Anti-Tank Ditch	AA0002
5	Operations 1	Bridge	AA0005
7	Enemy	Free Draw	AA0004
8	Obstacle	Minefield	AA0003
10	Obstacle	Anti-tank Ditch	AA0006
12	Operations 1	Bridge	AA0007
14	Enemy	Free Draw	AA0008

Appendix E

Report Task Elements

Task Number	TGT 1/ Subtype/No.	TGT 2/ Subtype/No.	Friendly Action	Enemy Activity
2	APC/BMP/2	TANK/T72/4	Continue	Withdraw
4	APC/BRDM/4	TANK/T80/2	Observing	Reconn
6	ARTILLERY/SP/6	APC/BTR/2	Observing	Defending
9	APC/BMP/4	TANK/T72/2	Continue	Withdraw
11	APC/BRDM/2	TANK/T80/4	Observing	Reconn
13	ARTILLERY/SP/4	APC/BTR/4	Observing	Defending

Appendix F

Essential IVIS Task Success Criteria

IVIS Overlay and Report Data Elements Required for Success

Essential IVIS overlay information elements

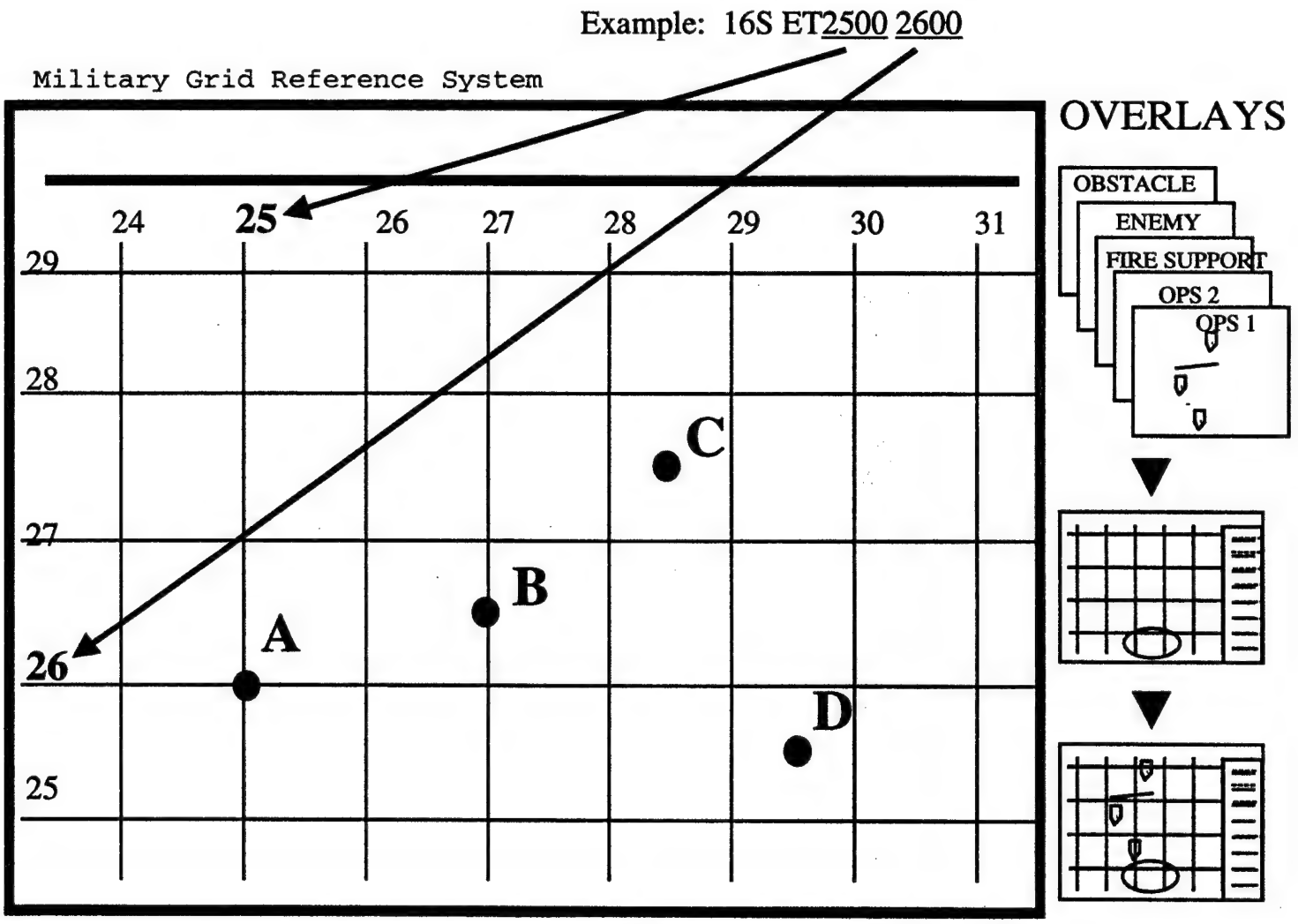
1. Select the correct IVIS Overlay.
2. Select the correct multi-point graphic.
3. Place the multi-point graphic at the correct location (+/- 100 meters).
4. Place a TRP at the correct location (requires exact coordinates entered with keypad).
5. Label the TRP (either left or right side) to include the correct two letters and four digits (ex. AA0006).
6. Send the Overlay over RT A or RT A/B.

Essential IVIS report information elements

1. Select the correct IVIS Report type (Spot Report)
2. Place the target icon graphic on the tactical display at the correct location (+/- 100 meters)
3. Enter the specified Target 1 type
4. Enter the specified Target 1 subtype
5. Enter the specified Target 1 size
6. Enter the specified Target 2 type
7. Enter the specified Target 2 subtype
8. Enter the specified Target 2 size
9. Enter the specified Type of Enemy Activity
10. Enter the specified Type of Friendly Action
11. Send the Overlay over RT A or RT A/B.

Note. Entering extra targets with a size other than zero constitutes failure. Sending a second report over the same net constitutes failure as second report overwrites first with a blank report.

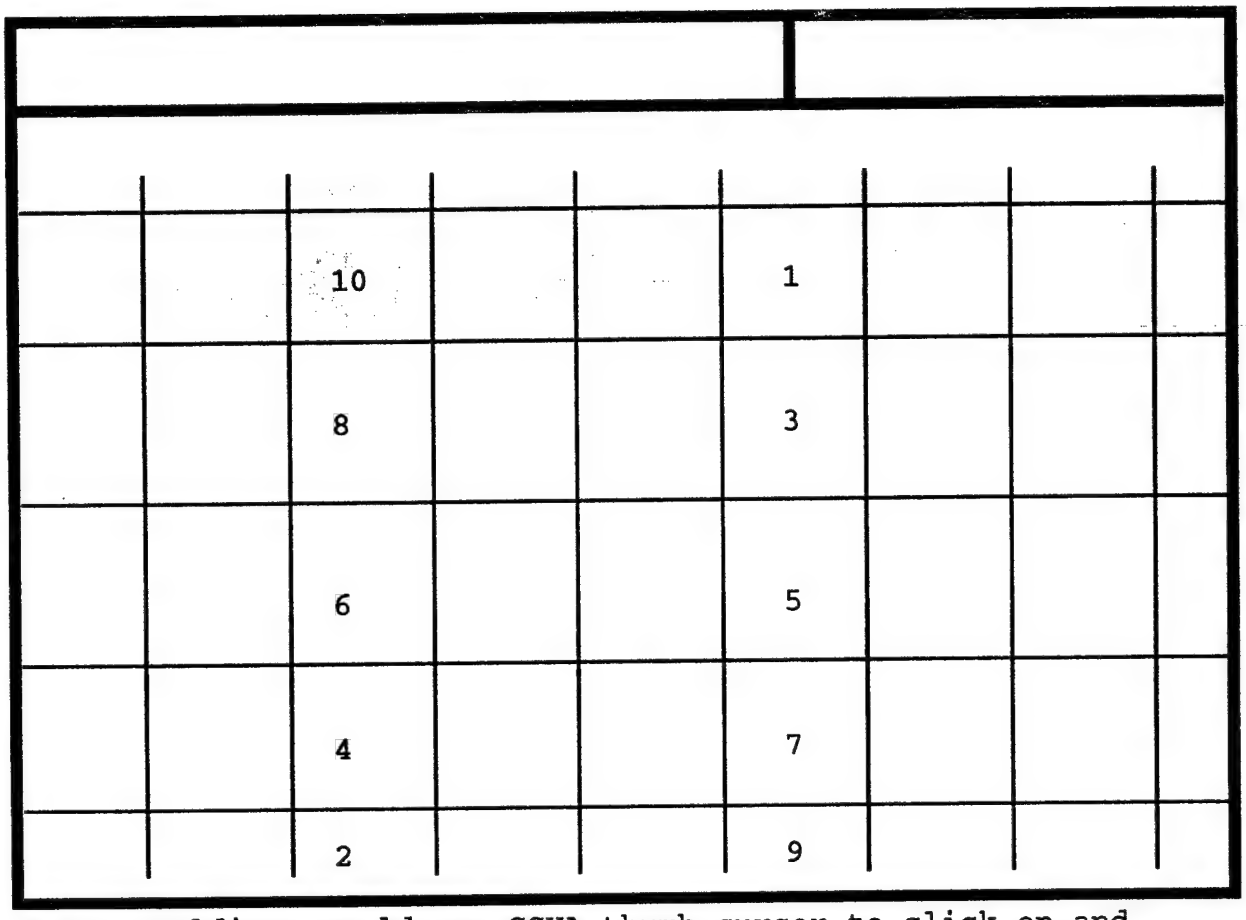
APPENDIX G GOES HERE



Thumb cursor standard = +/- 10 Example: 2550 = 2540 to 2560

Appendix H

Psychomotor Ten Digit Task



Note. Soldiers would use CCHA thumb cursor to click on and highlight numbers in numerical sequence beginning with number 1 and ending with number 10.

Appendix I

Demographic Data Survey

PT 60-15

DIGITAL SKILL RETENTION
DEMOGRAPHIC SURVEY

NAME:_____ SOCIAL SECURITY NUMBER:_____
PIN:_____

1. BC/MOS: _____ 2. Rank/Grade: _____ 3. Age: _____

4. Time in Military Service:
Officer: Years _____ Months _____
Enlisted: Years _____ Months _____

5. Circle your current duty position/assignment:

Driver Loader Gunner Tank Cdr Plt Sgt Plt Ldr Co XO Co Cdr
Other: (please describe) _____

6. Have you trained and/or had experience with any digital equipment used in the M1A2 tank or similar systems? Please list by type (i.e., SINCGARS, IVIS, Applique, B2C2, ASAS), training received and/or experience, and dates.

_____
_____
_____
_____

7. If you related your experience with computers in terms of years, where would you place yourself on the chart below? (Circle a number please.)

1	2	3	4	5
No experience	less than 1 year	more than 1 year	more than 3 years	5 years or more

8. Approximately how often do you use a computer each month? (Circle a number please.)

1	2	3	4	5
Never	Once a month	Once a week	2-3 times per week	Daily

9. Do you use Windows (or a Windows-type software [Win 3.11, Win 95, MAC]) while using a computer?

_____ Yes
_____ No

10. Please circle the value that best describes how you feel (in general) about using computers.

1	2	3	4	5
Very Uncomfortable	Uncomfortable	Neutral	Comfortable	Very Comfortable

11. Please check your highest civilian education level achieved:

_____ High school diploma/GED

_____ Some college

_____ College degree (BA/BS)

_____ Graduate-level courses (no graduate degree)

_____ Graduate degree (MA/MS)

Appendix J

Summary of Demographic Data

1. BC/MOS: All are 19K qualified

2. Rank/Grade: 7 E-2 4 E-3 12 E-4 5 E-5

3. Average age: 22.29 years

4. Average time in military service? 2 years 11 months

5. Duty Position.

   13 Driver 2 Loader 6 Gunner 4 Tank Cdr 3 Other

6. Digital equipment training

   13 None 15 SINCGARS 0 IVIS

6. Experience with computers, years of experience.

   6 No Experience 11 Less Than 1 Year 4 More Than 1 Year

   5 More Than 3 Years 2 5 Years Or More

7. How often do you use a computer each month?

   8 Never 12 Once A Month 3 Once A Week

   2 2-3 Times Per Week 3 Daily

8. Do you use Windows while using a computer? 19 Yes 9 No

9. Describe how you feel about using computers?

   1 Very Uncomfortable 1 Uncomfortable 9 Neutral

   12 Comfortable 5 Very Comfortable

10. Highest civilian education level.

    14 High School Diploma 13 Some College
    1 College Degree (BA/BS)

Appendix K

Overlay Trials Success and Time Summary

Overlay Trial	Success Rate	Performance Time (sec)	
		M	SD
Day 1 Session (n = 28)			
Trial 1 (First Day 1)	.68	219.64	59.20
Trial 3	.61	228.57	67.71
Trial 5	.79	194.39	56.11
Trial 7 (Last Day 1)	.74	188.63	51.75
Day 30 Session (n = 27)			
Trial 8 (First Day 30)	.22	464.00	214.40
Trial 10	.41	351.50	212.43
Trial 12	.44	258.81	168.59
Trial 14 (Last Day 30)	.41	214.62	83.28

Note. Time data includes unsuccessful trials. One overlay performance time value for Trial 5 (406 seconds) was identified as falling more than three standard deviations beyond the mean for that particular trial. Following the data trimming approach outlined in Marascuilo and McSweeney (1977) this value was replaced with the next lowest time value and the lowest time value was replaced with the next highest value.

Appendix L

Report Trials Success and Time Summary

Report Trial	Success Rate	Performance Time (sec) M	SD
Day 1 Session (n = 28)			
Trial 2 (First Day 1)	.71	165.04	58.90
Trial 4	.74	126.74	44.00
Trial 6 (Last Day 1)	.82	109.64	26.95
Day 30 Session (n = 27)			
Trial 9 (First Day 30)	.67	214.04	143.02
Trial 11	.63	127.37	41.49
Trial 13 (Last Day 30)	.70	128.37	83.37

Note. Time data includes unsuccessful trials. Four report performance time values were identified as falling more than three standard deviations beyond the mean for that particular trial, Trial 2 (555), Trial 4 (281), Trial 9 (865), and Trial 11 (697). Following the data trimming approach outlined in Marascuilo and McSweeney (1977) each value was replaced with the next lowest time value and the lowest time value was replaced with the next highest value.

Appendix M

Overlay Trials Summary For Skill Acquired Group

Overlay Trial	Success Rate		Performance Time (sec)		
	Rate	n	M	SD	n
DAY 1 SESSION					
Trial 1 (First Day 1)	.82	22	213.11	56.97	18
Trial 3	.73	22	210.81	59.45	16
Trial 5	.95	22	186.48	54.27	21
Trial 7 (Last Day 1)	.86	22	180.26	44.64	19
DAY 30 SESSION					
Trial 8 (First Day 30)	.29	21	509.00	199.57	6
Trial 10	.48	21	275.70	82.92	10
Trial 12	.52	21	202.82	44.29	11
Trial 14 (Last Day 30)	.48	21	183.20	60.96	10

Note. Table includes only successful trial times.

Appendix N

Report Trials Summary for Skill Acquired Group

Report Trial	Success Rate Rate	n	Performance Time (sec) M	SD	n
DAY 1 SESSION					
Trial 2 (First Day 1)	.83	23	146.84	36.95	19
Trial 4	.91	22	125.15	44.03	20
Trial 6 (Last Day 1)	.91	23	106.24	23.07	21
DAY 30 SESSION					
Trial 9 (First Day 30)	.77	22	180.71	117.24	17
Trial 11	.68	22	115.53	25.93	15
Trial 13 (Last Day 30)	.77	22	116.65	43.94	17

Note. Table includes only successful trial times.

Appendix O

Overlay Task Success Comparisons

Trial Contrast	Trial Success Comparisons: Proportion Successful	Difference	Sig.
Learning:			
First Day 1 vs.	.82	.040	.500
Last Day 1	.86		
Retention 1:			
Last Day 1 vs.	.86	-.570	.001**
First Day 30	.29		
Retention 2:			
Last Day 1 vs.	.86	-.380	.029*
Last Day 30	.48		
Recovery:			
First Day 30 vs.	.29	.190	.109
Last Day 30	.48		
Overlay Skilled			
Day 1 vs.	1.00	.520	.000**
Day 30	.48		

Note. McNemar test of related proportions, exact significance (1-tailed). n = 22 for Day 1 comparisons. n = 21 for comparisons that include Day 30 trials.
*p < .05. **p < .001.

Appendix P

Report Task Success Comparisons

Trial Contrast	Trial Success Comparisons: Proportion Successful	Difference	Sig.
Learning:			
First Day 1 vs.	.83	.080	.344
Last Day 1	.91		
Retention 1:			
Last Day 1 vs.	.91	-.140	.188
First Day 30	.77		
Retention 2:			
Last Day 1 vs.	.91	-.140	.188
Last Day 30	.77		
Recovery:			
First Day 30 vs.	.77	.000	.688
Last Day 30	.77		
Report Skilled			
Day 1 vs.	1.00	.230	.003*
Day 30	.77		

Note. McNemar test of related proportions, exact significance (1-tailed). n = 23 for Day 1 comparisons. n = 22 for comparisons that include Day 30 trials.
*p < .05.

Appendix Q

Overlay Task Time Comparisons

Trial Contrast	M	SD	Diff.	t/df	Sig.
Learning:					
First Day 1 vs.	213.80	61.97	-34.47	2.994/14	.010**
Last Day 1	179.33	35.69			
Retention 1:					
Last Day 1 vs.	196.00	47.65	-321.40	3.861/4	.018*
First Day 30	518.00	221.77			
Retention 2:					
Last Day 1 vs.	177.86	51.26	-17.71	1.723/6	.136
Last Day 30	164.38	31.07			
Recovery:					
First Day 30 vs.	491.40	217.86	-315.20	3.688/4	.021*
Last Day 30	179.17	30.09			

Note. Paired sample t-test (2-tailed).
*p < .05. ** p < .01.

Appendix R

Report Task Time Comparisons

Trial Contrast	M	SD	Diff.	t/df	Sig.
Learning:					
First Day 1 vs.	147.65	39.05	-46.24	6.208/16	.000*
Last Day 1	101.41	18.23			
Retention 1:					
Last Day 1 vs.	101.94	24.84	52.38	5.383/15	.000*
First Day 30	154.31	45.05			
Retention 2:					
Last Day 1 vs.	103.75	24.72	15.00	1.327/15	.204
Last Day 30	118.75	44.49			
Recovery:					
First Day 30 vs.	186.73	124.00	-71.33	2.020/14	.063
Last Day 30	115.40	46.38			

Note. Paired sample t-test (2-tailed).
*p < .001.

Appendix S

Skill Retention Ratings

Scale Question	Overlay Task	Report Task
1. Job/Memory Aid		
Yes = 1	1	1
No = 0 (Go to 3)		
2. Job/Memory Aid Quality		
Excellent = 56 (Go to 6)		
Very Good = 25		25
Marginally Good = 2		
Poor = 1	1	
3. Number of Steps		
1 Step = 25 (Go to 6)		
2 to 5 Steps = 14		
6 to 10 Steps = 12		
More than 10 = 0	0	0
4. Sequence		
None Are = 10		
All Are = 5		
Some Are, Some Are Not = 0	0	0
5. Feedback		
For All Steps = 22		
For Most Steps = 19	19	19
Only a Few = 11		
None = 0		
6. Time		
None = 40	40	40
Easy = 35		
Difficult = 0		
7. Mental Requirements		
Almost None = 37	37	37
Simple = 28		
Complex = 3		
Very Complex = 0		

Retention Scale Ratings (continued)

Scale Question	Overlay Task	Report Task
8. Number of Facts		
None = 20		
A Few (1-3) = 18		
Some (4-8) = 13		13
More than 8) = 0	0	
9. How Hard to Remember		
Not Applicable = 34		
Not Hard At All = 31		31
Somewhat Hard = 12	12	
Very Hard = 0		
10. Motor Control Requirements		
None = 2		
Small = 0		0
Considerable = 16	16	
Very Great = 3		
Total Score	126	166
Estimated Retention After 30 Days	67%	92%

Appendix T

Subtask Step Errors and Recommendations

Summary of Frequent Overlay Subtask Step Errors (All Trials)

Subtask	Task Step Error	Description/Recommendation
Navigate to Overlay	104: Select an Overlay	Fails to recognize interface requirement to highlight an overlay from menu. Recommend: Increase training emphasis, add "Select an Overlay" message when Overlay menu displayed.
Multiple Point Graphic	204: Grid points wrong	Fails to remember how to plot simple MGRS coords. Recommend: Increase MGRS training emphasis?
TRP Graphic	303: Cursor used to enter coord	Fails to remember that cursor is not accurate enough for TRP coord. Recommend: Add illustration examples comparing cursor and keypad accuracy.
Send Overlay	405: Select an Overlay	Fails to recognize interface requirement to highlight an overlay from menu. Recommend: Increase training emphasis, add "Select an Overlay" message when Overlay menu displayed.

Summary of Frequent Report Subtask Step Errors (All Trials)

Subtask	Task Step Error	Description/Recommendation
Navigate to Report	No errors	No errors
Enter Target Grid	601: Grid points wrong	Fails to remember how to plot simple MGRS coords. Recommend: May be limited to experiment, normally lazing inserts target icon.
Target Description	709: Bad data from unsent report remains	Failure to send previous report, and can't overwrite old data with new data. Recommend: No data overwrite procedure in Lesson Plan. Create one and train it. Change software to dump data after exiting report mode?
Friendly/ Enemy Activity	806: Selects DIAG mode after entering data	Ends the task after entering Report data, forgets to send the report. Recommend: May be limited to experiment. Graphics mode prompts operator to SAVE, Report mode software could prompt to SEND.
Send Report	908: DIAG mode after SEND	Fails to select CONFIRM RT A after selecting SEND option. Recommend: Train that SEND does not actually send. Report mode software could prompt to CONFIRM RT.

Appendix U

Overlay and Report Task Step Errors

Frequency of Overlay Day 1 and Day 30 Task Step Errors

Code	Step Number and Description	Day 1	Day 30	Total
100	**NAVIGATE TO OVERLAY GRAPHICS**	2	14	16
101	1. Select PRE/POST			
102	2. Select MISSION PLANNING			
103	3. Select EDIT OVERLAY		1	1
104	4. Select correct overlay	2	9	11
105	5. Select GRAPHICS			
106	6. PAGE DOWN/UP to select graphic		1	1
125	Coaching Required		4	4
200	**TWO-POINT GRAPHIC**	17	37	54
201	7. Select two-point graphic (wrong one)	1		1
202	Select two-point graphic (no select)		1	1
203	8. Use cursor for grid points	3		3
204	9. Both grid points correct	9	9	18
205	Extra two-point graphic applied		1	1
206	10. Press RETURN to exit graphic	1	8	9
207	Selects "CONTINUE"	2	17	19
208	Selects "DIAG" after two-point	1	1	2
300	**TRP GRAPHIC**	33	105	138
301	11. Select TRP graphic (wrong graphic)		1	1
302	Select TRP graphic (none selected)	3	5	8
303	12. Use keypad to enter TRP	10	14	24
304	13. TRP grid point correct		3	3
305	14. Select RETURN (not required)			
306	15. Select LABEL			
307	16. TRP label content correct		1	1
308	17. TRP labeled on left side	7	54	61
309	Two-point graphic labeled			
310	18. Select RETURN (exit TRP menu)		4	4
311	Extra graphic applied	5	10	15
312	Label text accurate	2	6	8
313	TRP Deleted	1	1	2
314	Selects DIAG after TRP labeled	3	5	8
315	Exit and return	2	1	3

Frequency of Overlay Task Step Errors (continued)

400	**SAVE AND SEND OVERLAY**	13	51	64
401	19. Select SAVE CHANGES		7	7
	Saves by selecting a MODE			
402	Saves by going to SAVE prompt	1	3	4
403	20. Select SEND OVERLAY	6	2	8
404	Selects DIAG after SEND OVERLAY		7	7
405	21. Select overlay to send (no select)		14	14
406	Select overlay to send (wrong one)	1		1
407	22. Select STANDARD ROUTING			
408	23. Confirm on RT A			
409	Selects RT A/B		9	9
410	Selects RT B			
411	Duplicate overlay(s) sent	1	1	2
412	Select DIAG			
413	DIAG selected after SAVE	1	1	2
414	No SAVE/SEND actions	3	7	10

Frequency of Report Task Step Errors

Code	Step Number and Description	Day 1	Day 30	Total
500	**Navigate to Spot Report**	0	1	1
501	1. Select COMBAT			
502	2. Press REPORTS			
503	3. Select IVIS REPORTS			
504	4. Select SPOT REPORTS		1	1
600	**Enter Target Grid**	11	12	23
601	5. Enter correct target grid coord	1	4	5
602	6. Cursor used to enter target grid	9	5	14
603	Target grid not entered	1	3	4
700	**Enter Target Description Data**	10	6	16
701	7. Select first target type			
702	8. Select first target sub-type	1	2	3
703	9. Enter first target size with keypad	1		1
704	10. Select second target type	2	1	3
705	11. Select second target sub-type			
706	12. Enter second target size with keypad	1		1
707	Target data not entered	1		1
708	Only one target type entered			
709	Tgt. data from unsent report remains	2	2	4
710	Selects DIAG after entering tgt data			
711	Target data entered twice	1		1
712	Can't eliminate bad target data	1	1	2

Frequency of Report Task Step Errors (continued)

800	**Enter Friendly Actions/Enemy Activity**	10	14	24
801	13. Select ACTIVITY	1	1	2
802	14. Select activity type		1	1
803	15. Select FRIENDLY ACTION	1	4	5
804	16. Select action type	2		2
805	This code not used			
806	Selects DIAG after friend/enemy data	3	5	8
807	No friendly or enemy info entered	3	3	6
900	**Send Report**	4	25	29
901	17. Select SEND	1	2	3
902	18. Select STD ROUTING			
903	19. Select CONFIRM RT A			
904	Select CONFIRM RT A/B		10	10
905	Select CONFIRM RT B		2	2
906	Duplicate report sent (blank)	2	2	4
907	Select DIAG			
908	Go directly to DIAG after SEND		4	4
909	Code not used			
910	No SEND actions taken	1	5	6
911	Technical problem (cursor drift)			

Note. Errors are for full sample of soldiers, not restricted to the Skill Acquisition groups, $\underline{n}$ = 28. Each soldier may contribute more than one error per subtask per trial.

Appendix V

Intercorrelations Between Psychomotor Trial (Motor) Time, and Successful Overlay and Report Trials

Measure	1	2	3	4	5	6	7	8
1. Motor 1	--	.59**	.64**	.45**	.00	.18	.25	.27
2. Motor 2		--	.34*	.30	.02	-.09	.16	.26
3. Motor 3 (Day 30)			--	.57**	-.13	.18	.30	.32
4. Motor 4 (Day 30)				--	-.01	.38*	.12	.24
5. Overlay Total (Day 1)					--	.44*	.47**	.31
6. Overlay Total (Day 30)						--	.48**	.41*
7. Report Total (Day 1)							--	.48**
8. Report Total (Day 30)								--

Note. n = 28 for correlations (1-tailed) based exclusively on Day 1 scores. n = 27 for correlations (1-tailed) that include Day 30 scores.
*p < .05.. **p < .01.

Appendix W

Psychomotor Test Time Comparisons

Trial Contrast	M	SD	Diff.	t/df	Sig.
Learning:					
First Day 1 vs.	90	23	23.45	5.484/21	.000**
Last Day 1	67	7			
Retention 1:					
Last Day 1 vs.	66	7	-2.57	1.352/20	.191
First Day 30	69	9			
Retention 2:					
Last Day 1 vs.	66	7	2.29	1.139/20	.268
Last Day 30	64	7			
Recovery:					
First Day 30 vs.	69	8	4.86	2.861/20	.010*
Last Day 30	64	8			

Note. Sample is restricted to Overlay Skilled group.
Comparisons are paired t-tests (2-tailed).
*p < .01. **p < .001.

Appendix X

Correlations Between Declarative Knowledge (DK) Scores and Task Success

Measure	1	2	3	4	5	6	7
1. Day 1 DK	--	.43*	.60**	.57**	.35*	.59**	.68**
2. First Day 30 DK	--	.14	.15	.35*	.42*	.43*	
3. Last Day 30 DK		--	.17	.06	.29	.35*	
4. Overlay Day 1 Total			--	.44*	.47**	.31	
5. Overlay Day 30 Total				--	.48**	.41*	
6. Report Day 1 Total					--	.48**	
7. Report Day 30 Total						--	

Note. n = 28 for correlations (1-tailed) based exclusively on Day 1 scores. n = 27 for correlations (1-tailed) that include Day 30 scores.
*p < .05.. **p < .01.

Appendix Y

Declarative Knowledge Test Comparisons

Trial Contrast	M	SD	Diff.	t/df	Sig.
Retention 1:					
Last Day 1 vs.	6.33	1.06	-1.86	6.669/20	.000*
First Day 30	4.84	1.25			
Retention 2:					
Last Day 1 vs.	6.33	1.06	-.33	1.435/20	.167
Last Day 30	6.00	0.89			
Recovery:					
First Day 30 vs.	4.48	1.25	1.52	4.544/20	.000*
Last Day 30	6.00	0.89			

Note. Sample is restricted to Overlay Skilled group. Comparisons are paired sample t-tests (2-tailed).
*$p < .001$.

Appendix Z

Correlations Between Demographic Characteristics and Day 30 Trial Success

Demographic Factor	Correlation With Day 30 Total of Successful Trials (r/sig.) Overlays	Reports
Rank (E2 - E5)	.114/.287	.000/1.000
Age (20 - 29)	.084/.679	.015/.943
Duty Position (1 = Tank CDR, 0 = other)	.232/.244	.176/.381
Time in service (months) (9 - 120)	.147/.465	.178/.357
Highest education level (HS Degree - College)	-.165/.410	.051/.802
Use computer each month (Never - Daily)	.411/.033*	.110/.584
Computer experience (None - 5 yrs or more)	.088/.663	.407/.035*
Do you use Windows (yes/no)	-.204/.308	-.242/.224

Note. n = 27 due to transfer of one soldier.
*p < .05 (2-tailed).